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THE SAN FRANCISCO.

MINING INSTITUTE

OF SCOTLAND.

TRANSACTIONS,

Vol. X.—1888-89.

HAMILTON:
PRINTED BY W. NAISMITH, CAMPBELL STREET.

MDCCCLXXXIX.

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THE MINING INSTITUTE OF SCOTLAND.

ELEVENTH ANNUAL MEETING,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

26th April, 1888.

JAMES S. DIXON, Esq., in the Chair.

About 30 members were present.

The minutes of the last General Meeting were read by the Secretary and confirmed.

COUNCIL'S REPORT.

The SECRETARY read the report of the Council as follows:—

At the period of presenting this, the Tenth Annual Report, the Council are happily able to state that the membership of the Institute shows decided signs of improvement in two directions. The number on the roll is the largest reached during the history of the Institute, whilst the number of names removed on account of non-payment of subscription is less by five than in the previous year. The membership statement stands thus:—

Number on the roll at last Annual Meeting,		...	469
Additions, ...	56		
Resignations, ...	5		
Deaths, ...	5		
Names struck off the roll, ...	28		
	—	38	
Net increase, ...		—	18
Making at this date a total membership of		...	487

It is gratifying to observe from these figures that interest in the work of the Institute is spreading among those engaged in colliery work, and it is hoped that ere long the coalmasters and

proprietors of minerals in this country will see it to be their true interest to give a larger measure of their personal encouragement to the Institute, as a means of increasing the general fund of technical information connected with the great industries which it embraces.

The papers presented to the Institute during the year maintain the average of excellence and usefulness, while some, of course, have excited more discussion than others. The following is a list of the subjects dealt with in papers or reports, which, with discussions, have been printed in the Transactions :—

A Mining Tour through South Africa (the Gold Fields).
The Coal Mines Regulation Bill, 1887.
Safety Lamps.
The Schiele Colliery Ventilator.
Exploring a Mine after a serious Explosion.
Excursion to Newcastle and neighbourhood, with description of collieries visited.
Electrical Appliances and Haulage Exhibits at the Newcastle Exhibition.
Ackroyd and Best's Safety Lamp-cleaning Machine.
Proposed Schemes for Keeping Mines clear of Inflammable Gas.
Air-agitated Coal Washer.
The General Principles of Coal Washing.
A System of Endless Rope Haulage at Newbattle Collieries.

The Annual Summer Excursion had for its destination the Exhibition at Newcastle, and various collieries in its vicinity, and formed a very agreeable feature of the session. Previously, the excursion had been confined to places of interest in Scotland. The occasion afforded of enabling members to compare other mining methods with those in use amongst ourselves was largely taken advantage of, and was found very valuable. The number of members who availed themselves of the opportunity was greater than in any of our former excursions, there being over 120, and the reports and papers subsequently contributed to the Institute bear ample testimony to the profit and pleasure derived from the excursion.

A new catalogue of the Library has just been issued. A perusal of it will shew that many valuable books have been added, and the Ordnance Survey maps on the six inch scale, embracing all the coal fields of Scotland, have now been procured.

The following is a list of donations received during the year :—

DONOR.	DONATION.
C. HUNTER, ...	... "Iron and Steel Manufacture," by Ferdinand Kohn.
THOS. W. NEVILL, ...	... "Geology of Newfoundland."
B. H. BROUGH, ...	... Pamphlet on "Use of the Magnetic Needle in Exploring for Iron Ore."
PROPRIETORS OF "ENGINEERING,"	"Cable or Rope Traction," by Buchnal Smith.
A. M. GRANT, ...	... "Cable or Rope Traction," by Buchnal Smith.
J. M. RONALDSON, ...	... Mining and Mineral Statistics for 1886.
D. A. W. ROBERTSON, ...	... Report of Royal Commission on the Accidents at Ferndale Colliery, New South Wales, 1885-86, and at Lithgow Valley Colliery, New South Wales, 1885-86.
EDITOR OF "ENGINEERING,"	... "Metallurgy of Silver, Gold, and Mercury in the United States." Vol. I. —Silver—Egleston.
WILLIAM DUFF, ...	... Illustrated Catalogue of S. Owens & Coy.—Hydraulic, Gas, and General Engineers, London.
DR JOHN ROBERTSON, ...	... Report by Royal Commission on Accidents at Lithgow Valley Colliery, New South Wales, 1885-86; at Ferndale Colliery, New South Wales, 1885-86; on Bulli Colliery Accident, N.S.W., 1887; and on the condition of the collieries adjacent to Ferndale, 1887.
W. J. POTTS, ...	... Potts's Mining Register and Directory.
C. M. PERCY, ...	... Pamphlet on "Mine Rents and Mineral Royalties"—two copies, one bound.
THE SECRETARY OF STATE,	... Reports of Inspectors of Mines, 1886; and Report of the Commissioners on Udston Colliery Explosion, 1887.

There have been fifteen meetings of Council during the year.

The PRESIDENT congratulated the Institute on the exhaustive report which they had just heard read, and which he formally put to them for their acceptance. (Applause.)

FINANCIAL REPORT.

The SECRETARY read the following Abstract of Accounts for the past year, duly audited :—

CALIFORNIA STATE
Mining Bureau,
SAN FRANCISCO.

ABSTRACT of ACCOUNTS for Session 1887-88.

Receipts.

To Balance from 1886-87,			£155	4	1½
,, 179 Members' Subscriptions at 21s,			187	19	0
,, 1 Do. do. 20s 6d,			1	0	6
,, 263 Do. do. 10s 6d,			138	1	6
,, 12 Do. do. arrears, 21s,			12	12	0
,, 14 Do. do. do., 10s 6d,			7	7	0
,, Received for Transactions, Titles, &c.,			13	2	8½
,, Do. Rents for Hall,			14	13	6
,, Do. Advertisements,			6	6	0
,, Do. Bank Interest,			3	9	9
			£539	16	1

Payments.

By Printing and Stationery,			£167	3	9
,, Books, Maps, and Bookbinding,			39	9	7
,, Rents of Halls,			16	3	1
,, Gas and Assessments,			3	6	3
,, Stamps, Carriages, &c.,			11	4	6½
,, Sundry Payments,			1	1	1
,, Salaries,			67	12	0
,, Cleaning,			6	0	0
,, Balance in Bank,	£227	15 8			
,, Do. Treasurer's hands,	0	0 1½			
			227	15	9½
			£539	16	1

16th April, 1888.—Examined, compared with vouchers, and found correct.

H. JOHNSTONE,
J. B. DALZELL, } AUDITORS.

THE PRESIDENT said he thought this balance sheet very satisfactory indeed. They began the year with £155 4s 1½d, and now they had in bank £227 15s 9½d. They were now in a much better financial position than ever before.

ELECTION OF OFFICE-BEARERS.

The CHAIRMAN announced that the following gentlemen, who had been nominated as office-bearers for the ensuing year at last general meeting, were now duly elected :—

President :

JOHN M. RONALDSON, 44 Athole Gardens, Glasgow.

Vice-Presidents :

JAMES SMART, Balgreen, Hamilton.
DAVID ANDERSON, Bothwell Road, Hamilton.
HENRY AITKEN, Darroch, Falkirk.
FRED J. ROWAN, 121 West Regent Street, Glasgow.

Councillors :

THOMAS ARNOTT, Clyde Cottage, Tollcross.
THOMAS M. BROWN, Lanemark Colliery, New Cumnock.
JAMES GILCHRIST, Earnock Colliery, Hamilton.
ALEX. M. GRANT, Townholm, Kilmarnock.
JAMES HASTIE, Greenfield Colliery, Hamilton.
JOHN HOGG, North Motherwell Colliery, Motherwell.
HUGH JOHNSTONE, Portland Park, Hamilton.
ROBERT M'LAREN, Crofthill Place, Uddingston.
ROBERT THOS. MOORE, 134 St. Vincent Street, Glasgow.
JOHN MORISON, Newbattle Collieries, Dalkeith.
JAMES PRENTICE, Stanrigg Collieries, Airdrie.
MICHAEL ROSS, Eddlewood Colliery, Hamilton.

The following gentlemen were elected by ballot as ordinary members :—

ROBT. KERR, West Hallhill Colliery, Baillieston.
Rev. THOS. M. B. PATERSON, Ardenclutha, Hamilton.
J. B. HAMILTON, Bourtreehill, Hamilton.
ALEX. EASTON, Westburn Colliery, Cambuslang.
JOHN MILLAR, Langloan Iron Works, Coatbridge.

VOTE OF THANKS TO THE RETIRING PRESIDENT.

Mr F. J. ROWAN said, before they allowed Mr Dixon to vacate the chair, which he had occupied with so much acceptance and so much ability for three years, he begged to ask their permission to

propose a very hearty vote of thanks to him. The qualities required in the president of an institution like this were not always very easily found. He need not say anything about Mr Dixon's technical skill and ability, because these were well known to them all. What was not known, except to those who had been intimately associated with him in, so to speak, the underground work of the institute, was the self-denial that was necessary in a president who really works—giving up his time and devoting himself to the interests of the Institute; and combined with that, what was also required, and had been found in Mr Dixon, unfailing good nature and urbanity, which had made it pleasant for all those associated with him in the work of the Council. And it was because he knew a little of the assiduity and care and self-denial with which Mr Dixon had devoted himself to the work of the Institute, in addition to his skill in the chair, which had been patent to them all, that he begged to propose that they give him a very hearty vote of thanks for his conduct at the helm of the Institute for so long. (Applause.)

The EX-PRESIDENT, in response, said he had had great pleasure indeed in devoting any little time and attention that he had done to the interests and the work of the Institute. He had to thank the members generally, and those of the Council in particular, for the great kindness that they had always displayed towards him while occupying the President's chair. To them more than to the occupant of the chair was due the harmonious way in which their meetings had been conducted. In demitting office, he was very glad indeed that they had chosen such a gentleman as Mr Ronaldson to follow him in the Presidency. (Applause.) From his varied experience in mining, and from all the qualities he was known to possess, he was eminently fitted for the position; and all he would add, in vacating the chair, was the wish that the Institute, under Mr Ronaldson, might have the same prosperity and the same influence for good as it had had during the last ten years. He heartily hoped the Institute might go on and flourish. (Applause.)

Mr. DIXON then vacated the chair, and introduced the new President, Mr. JOHN M. RONALDSON, who delivered the following address :—

PRESIDENT'S ADDRESS.

GENTLEMEN,—At this, the opening meeting of a new session in the history of the Mining Institute of Scotland, as usual, we find a change in the composition of the Council. I had looked forward to retiring into the privacy of ordinary membership when I was unexpectedly asked to allow myself to be nominated as president. I heartily thank you for the honour you have done me in electing me president for the ensuing year; and, were it not for the knowledge that the success of the Institute, fortunately, does not depend mainly upon the ability of the president, I would not have ventured to accept a position so responsible. The secretary is a more important functionary, and we know who our secretary is, and what he has done in the past. New faces appear in the list of office-bearers, as it is right that they should do, but many tried members of council still remain, and as under wise guidance in the past our barque has been safely steered by the council, it is not too much to expect that in the future similar success will attend our efforts; and, if past success be not still maintained, we shall have no one to blame but ourselves. As regards the number of members, the state of the finances, and the quality of the papers, with the discussions thereon, it may safely be affirmed that our Institute has, to say the least, held its own with kindred societies.

As each year passes by, the more impressed I am with the good effects produced throughout the mining community by this Institute. We have members in the outlying districts who have few opportunities of interchanging ideas with their fellow-members, or of attending the meetings; but, by being put in possession of the transactions as they are issued, they know what is being done, and frequently have I noticed the great interest taken in the Institute by those who have never attended any of its meetings. Reference has repeatedly been made to the importance of members, who are unable to attend the meetings, contributing to the discussions by letter. I would again draw attention to this matter in the hope that, as by repeated blows a hole is at length drilled into the hardest rock, so by repeated request non-contributing members may be persuaded to give the

benefit of their experience. The working members have always been comparatively few in number, and it is but fair that the honour of contributing to the transactions should be widely distributed. There is no better help to fixing in the memory any subject than trying to write about it; and thus, if more members who have hitherto neither contributed papers nor taken part in the discussions would lend a helping hand in the manner indicated, they would benefit both themselves and the Institute.

In looking over the library catalogue, one cannot but observe the number of books on mining subjects the student now has at his disposal, as compared with what was available twenty years ago. Books on every conceivable subject, either directly or indirectly connected with mining, are to be found on these shelves; and, instead of being unable, as not so very long ago was the case, to lay his hands on books dealing with the subjects he desires to master, the mining student finds so many of all kinds thrust into his hands that his difficulty is to make a proper selection, or keep pace with the discoveries and inventions which are constantly being brought to light. In these days of high working pressure, it is not the man of mere rule of thumb practice, any more than the man of mere theory, who can make a colliery pay, but it is the man in whom theoretical knowledge and practical experience go hand in hand, each acting upon and controlling the other. In the library, books dealing with subjects both theoretically and practically are to be found; and, if we wish to keep abreast of the age, we must all be students—just as a doctor finds that he cannot lay aside medical books when he turns his back on college life, if he means to succeed as a practitioner.

There are few employments in which a knowledge of a greater variety of subjects is requisite than that of a modern mine manager. He is the better of having had a practical training in the mechanics' workshops; must be able to level and survey, design and draw plans; must have a knowledge of chemistry, geology, and mineralogy; must be well up in natural philosophy and other kindred subjects, in addition to being not only a mining but also a mechanical and civil engineer. In fact, he requires to be a sort of "Jack of all Trades," and the more of them he is the

master of, the better is he able to grapple with the many problems he has to solve. As a means of diffusing information, therefore, and of educating the members, the importance of such an Institute as this cannot be over-estimated.

On referring to the transactions published during the last nine years of our history, we find that a great variety of subjects have been treated, but there are many others well worthy of being brought under our notice, and that not necessarily by elaborate papers. As fresh light and fresh minds are constantly being brought to bear on subjects which, when we discussed them, were considered thrashed out, many of these might with profit be re-opened. There happened, a few days ago, another disastrous explosion of firedamp, resulting from an underground fire. A paper on how best to deal with the difficult problem of extinguishing underground fires, by some one who has had this experience, would form a valuable contribution. Many new explosives are being brought forward, especially on the Continent, with the object of displacing gunpowder in mines, and doing away with the recognised danger to life connected with its use. As stringent regulations introduced by the new Mines Act are now in force regarding blasting, an efficient and safe substitute for gunpowder is urgently required, and a paper bringing before us the latest information on this point would be welcomed. In all probability, safety lamps will be more extensively used than hitherto; and, although many minds have been and still are at work in the way of perfecting the invention of Sir Humphry Davy, so far as Scotland is concerned, *the* lamp of the future has not made its appearance in every-day use, although, judging from present appearances, there is every reason to expect that it will be found in the portable electric light.

Surprise is frequently expressed that, while machinery has displaced manual labour with marked success in almost all manufacturing processes, the principal work of the miner still continues to be performed by the hand-pick. Sufficient power for driving coal-cutting machines can readily be transmitted from the surface to the workings by means of compressed air, ropes, or electricity, but the difficulty to be overcome lies in getting machines at the same time sufficiently compact to take up little

space, portable so as to be easily conveyed from one part of the workings to another, and also so constructed as to keep well to the work they have to do. So far as I am aware, there is only one colliery in Scotland where coal-cutting machines have for some time been continuously in use, and still continue to give more economical results than manual labour. Doubtless, the comparatively low rate of wages earned by miners in recent years has had much to do towards delaying the extensive adoption of coal-cutting machines, which can best compete with hand labour when wages are high and the coal is difficult to work. If they were extensively adopted, a fewer number of persons for the same output would be employed, and fewer accidents by falls at the working face would consequently be the result.

In the matter of transit, the introduction of haulage machinery and the extended use of horses have done much to lessen the cost of conveying the coals to the shaft bottom. It is astonishing, however, still to find not a few cases where the drawers have to convey their hutches containing not more than four or five cwts. of coal a long distance. I have come across instances, not long since, where the drawers had to travel with their hutches a distance of over two miles for each ton of coal produced. Some screw is evidently loose where such a state of matters exists.

Turning to the ventilation of the mines, a marked general improvement has taken place during the time the Mines Regulation Act of 1872 was in force. I can imagine how the miners the other day felt when, as a candidate for Parliamentary honours addressed them, he told them that he saw death printed on most of their faces, and that they were being poisoned by foul air. I have not heard whether they believed him or not, but I saw it recently stated that registrars' statistics have conclusively proved that the average duration of a miner's life now compares favourably with that of workmen engaged in many other employments which have not been considered unhealthy. I do not say that the ventilation of our mines is everywhere what it should be, as there is still room for improvement in this direction in many cases, and especially in the stoop and room workings of non-fiery mines. A little fire-damp in some of these would not be a bad thing.

Coalmasters have now to face in the foreign markets a keener competition than hitherto from other countries; while over-production, resulting in keener competition at home, so keeps down prices, and consequently profits, that many believe mining in this country to be played out; but somehow or other we do not hear of good collieries being given up and left to lie idle on the landlords' hands, as is the case with farms. Many hold the view that, to meet the altered condition of things, royalties ought to be abolished. I give no opinion on this delicate subject, but I consider that we, as a Mining Institute, ought to do our utmost to help to get the mines to pay—first, by examining into and discussing new inventions, new systems of pumping, lighting, haulage, etc., that are brought before us, and, after rejecting what is of no value, and accepting what is good, giving the result of our investigations to the public.

A new Coal Mines Regulation Act came into operation on the 1st of January, but whether or not it will have the effect of diminishing the number of accidents, and what increased cost of working the mines it may entail, remain to be seen. Before concluding these rather disjointed remarks, I would refer briefly to a few of the many changes introduced by this Act.

By section 21, provision is made for a new official in the shape of an under-manager, whose duties, position, and qualifications have given rise to much discussion. Each mine in which more than thirty persons are employed underground requires to be under the daily personal supervision of either the manager or under-manager; the peculiarity of the position of the latter being that it is only in the absence of the former that the latter steps into his shoes and accepts all his responsibilities; and when the manager is present the under-manager, so far as responsibility is concerned, may simply be one of the workmen.

Section 34 renders it necessary that the workings be surveyed every three months instead of every six months, as formerly, with the addition, among other things, that the plans must show the general direction and rate of dip of the strata. To be of practical use, the latter requirement can be greatly improved upon by having marked all over the plan the levels of various points as

compared with a given datum line. Many mine owners have done this for a long time back and find it extremely useful.

Turning to the General Rules, we find in rule 4 an important alteration. Under the old Act, the inspection and report thereon, under General Rules 2 or 3, were only as far as ventilation was concerned; while the examination and report upon the state of the working places and roads under General Rule 29 could be made at any time in the 24 hours. Now, however, it is required that before the commencement of each shift (with the exceptions stated in the rule), a competent person must inspect every part of the mine in which workmen are to work or pass during that shift; and that not only as regards ventilation, but also so far as the roof and sides and general safety are concerned. As it must be stated in the report upon this inspection what defects (if any) in roofs or sides, and what (if any) other source of danger were or was observed, as well as where any gas was found present; and, as rule 21, which is the same as the old rule 16, specifies that the roof and sides of every travelling road and working place shall be made secure, and unless so made secure, no person shall travel or work in them, it is evident that this inspection does not mean simply a general look round by the fireman while making his morning rounds, but a minute and particular examination.

General Rule 8 provides that safety lamps alone shall be used in any place where there is likely to be such quantity of inflammable gas as to render the use of naked lights dangerous. The interpretation of this rule depends upon the construction put upon the meaning of the word *likely*. A high authority holds the rule to mean that where any derangement of ventilation permits inflammable gas to collect in any place, safety lamps are required to be used in that place, and in so much of the same ventilating district as is situated between that place and the return air-way.

In order to meet so far as possible the recognised danger connected with the use of explosives, and particularly in dry and dusty mines, an elaborate series of regulations have been embodied in General Rule 12. Every one must sincerely hope that thereby the desired end may be attained. One effect of this rule will be

that great care will be taken to carry the ventilating currents into every corner of the workings where fire-damp, in however small quantities, might possibly accumulate.

An entirely new feature in mining legislation is introduced in rule 34, and no one will grudge anything that will tend to alleviate the sufferings of those who have the misfortune to meet with an accident. It is gratifying to know that at so many of our mines members of the Ambulance Association are now to be found. First aid is often of the greatest importance in cases of accident, and lives may thereby be saved; and it is to be hoped that at every mine throughout the kingdom there will soon be found many, not only willing, but able to render efficient aid to their suffering fellow-workmen.

The EX-PRESIDENT (Mr Dixon) proposed a vote of thanks to Mr Ronaldson for his address, which was heartily awarded.

DISCUSSION OF MR A. M. GRANT'S PAPER ON "A SYSTEM OF ENDLESS ROPE HAULAGE AT NEW-BATTLE COLLIERIES."

The SECRETARY read the following communication from

Mr JOHN DRINNAN—I have been interested in the description of the new departure which has been made with respect to haulage by Mr Morison, but so far have been unable to see that he has done more than provided an additional factor of safety by his double rope. It may be that the discussion, which I hope will be full, will elicit more to its advantage; but meanwhile I am very sceptical with regard to the load on the ropes being equal. To effect this, there would require to be a nicety of tension not often seen in practical working, and that this nicety does not exist in Mr Morison's arrangement is sufficiently evidenced, I think, by Mr Grant's statement that when the speed of the ropes is unequal it adjusts itself by the rope which is going at the slower speed rising in the groove of its wheel, until the speed of each is again equal. The fact of its rising in the groove is a proof that it is carrying very little, if any, of the load, and it

can only remain at that higher level by reason of the other rope carrying the most, if not the whole, of the load, which practically means that the additional rope only affords some security that though one of the ropes should break, the tubs would not be allowed to break away. An ordinary "jock" would, I think, have served his purpose equally well, and would have cost much less for maintenance. Mr Grant's idea of applying the system for winding purposes is one which has frequently presented itself to my mind as calculated to prevent loss of life, or serious damage to property, by breakage of a winding rope. On very many pit-heads there could be fitted up, at comparatively little cost, a third pulley wheel, standing at right angles to and in front of the other two; and if over this pulley a rope was passed and attached to both cages, it would work in a similar way to the balance rope presently in use in some places, and by means of a screw it could be so nicely adjusted that it would bear no portion of the load when winding, but would immediately take hold if the winding rope gave way. If the rope carrying the loaded cage broke, there would be danger of the loaded cage immediately commencing to descend with more or less force, according to the weight of coal; but this could be prevented by having the attachment of the safety rope to the cage so constructed that when it took hold it would cause a clutch or clutches to seize the conductors. Otherwise, there might be an arrangement at the surface for applying a brake to the pulley wheels, over which the safety rope passed. Irrespective of the safety provided, such a system would permit of ropes being used to their utmost capacity, and would afford a test, not presently afforded, as to the best class of ropes; for, no matter though a rope exhibit little sign of wear, if it has been winding for three or four years, an inspector will consider that it ought to be taken off: indeed, Mr Stokes told me that if he knew it, he would not go down on a rope that had been in use for three years. I submit this with very great deference, for I have not maturely considered it.

Mr David Dunn said, like Mr Drinnan, he had failed to understand the advantages that were described in the paper in connection with this haulage. He could only repeat very much what had been read by the Secretary from Mr Drinnan.

Mr DIXON thought there was more in the second rope than either Mr Drinnan or Mr Dunn seemed to think. He thought it was of very great advantage, if it did nothing more than secure the hutches from running away. It did not matter whether the one rope was doing the work at one time and the other was doing comparatively little, if, in the event of one rope giving way, the hutches were prevented from running down. He might say, if he was to apply an endless rope haulage in such an incline, after the experience gained here in overcoming the difficulty, he would certainly adopt the two ropes, because they all knew the immense impetus with which the hutches, in the case of a break, would go down the incline, and would probably clear the road. He thought such an arrangement was essentially necessary in a slope of 30 degrees, which was a very steep incline. He thought the second rope was a departure which there must have been a great deal of thought given to in overcoming the difficulty of the one rope travelling quicker than the other. Therefore, he thought there was a great deal of credit due to Mr Morison or Mr Grant, or whoever proposed it. The proposal of Mr Drinnan, with regard to a second wheel on the pithead frame acting as a safety arrangement in the event of a break of the shaft rope, was certainly not new, because some years ago he read a paper on winding, in which that very thing was mentioned with a pulley and a rope attached to each cage in such a manner that, in the event of the winding rope breaking, it either stopped the cage entirely or let it down slowly.

Mr R. L. GALLOWAY said there was a safety rope employed in the Kœpe system, but he believed, where in use, they had abandoned it, and were trusting to the ropes alone.

Mr DUNN said he looked on the breaking away of tubs as the most dangerous feature in such an incline. If the person in charge brought himself to believe that there was additional safety in this double rope, might he not fall into the error that some mining people fell into with the safety cage? He knew of collieries where, during the time they worked with the safety cage, they had breakages of ropes, and before they put them on and after they took them off, they never had them. The people in charge were apt to say—"We need not concern our-

selves about these ropes; there is a safety cage on; there is no danger." Might that not occur in this arrangement? There also was suggested to his mind the possibility of a tub breaking away and colliding with the next, and thereby bringing about a breakage.

The PRESIDENT—Would that not be more likely with one rope than with two?

Mr HUGH JOHNSTONE thought that where two ropes were running there was as good a chance of their being attended to as where there was one. He did not know that he would quite go in with Mr Grant in the statement that he would get double wear out of the ropes on account of the possibility of running them to the extreme point where they had two, because any manager doing that would run a serious risk. If he did so, and one broke, the second would almost necessarily break too. Consequently, the upper tubs coming on the lower ones would cause a serious break. He asked whether the incline formed throughout one regular plane, or if it undulated.

Mr GRANT replied that it was perfectly straight, and on one uniform plane. It was very difficult to get a perfectly straight plane, and where there were undulations there was a risk of the rope lifting out of the grippers, allowing the hutch to run back on the next one, and to break away.

Mr Grant said he claimed for the system greater security and safety of working an incline such as this with heavy loads. Mr Dunn corroborated that, because that was a point he thought was not doubtful, and there was no doubt that was the point which they aimed at accomplishing when they proposed this system of haulage. With regard to the breaking away of tubs, he might tell them that such had happened. The tubs had broken away on more than one occasion, although in a very few instances, considering the system had been at work for two years and a half. The possibility of them breaking away was almost reduced to a minimum, because there were four grippers on each tub, two on each rope, and it was found on every occasion that a break away occurred, the one that was advancing stopped the other as it ran back, and the shock was not sufficient to break the second one away.

Mr DUNN said, perhaps Mr Grant would explain what was at fault in those breaks-away?

Mr GRANT said, unfortunately he was not able to give them the details of that. Of course, he was only describing in the paper what his firm erected and set to work, and he could not tell them the every day working of it. The point that was under consideration when the system was got up, was the very reverse of trusting to chance in the case of breaking away of tubs, and, of course, when he spoke of the ropes being run to their very last point, he meant the very last point of safety. That was the same as they would wear a winding rope. They would never dream of wearing a winding rope to the point when it was going to break. Neither did he mean them to do that with those ropes, because at any moment a full load might come upon the worn rope and it would break, and if the other was in the same state, it would break also. But with due care, all possibility of danger from breakage of ropes was reduced to a minimum in systems of this kind. With regard to the point Mr Drinnan spoke about—the uniform speed on the ropes: one of the chief considerations in getting up this system of haulage was to effect this. It was a likely thing that would occur, and, if one pulley was continually going faster that the other, there was no use of putting up the two ropes. They got up the elaborate arrangement described to overcome that, and found it was not required. He had described the way the pulleys themselves overcame it. He might mention that the one rope ran so little faster than the other, it was only at very rare intervals the whole weight was thrown on the other rope, and that only for a moment. Where it did so, the other overtook it, and the rope went on as before.

Mr ROBERT M'LAREN said he had the pleasure of seeing this haulage, and he thought the great feature was in having the two ropes. When the one went faster, the other overtook it, and having four grippers it made it safer. On one occasion that he saw it, one tub fell back on the other with no bad effect, whereas, if there had been only one rope and two grippers, the likelihood was that it would have gone back and cleared the incline entirely. As it was, it did not do any harm.

Mr HASTIE asked as to the tear and wear of the ropes.

Mr GRANT said he had stated in some portion of the paper how long the last rope had been in operation. He might mention that when the haulage was started there were two old ropes put on, or rather they were iron wire ropes. As they showed signs of wearing fast, it was decided to put on steel ropes, and though they had been in use for eighteen months, they still appeared to be like a new rope.

Mr STAFFORD explained that they were preparing to go back from the superior quality of steel to the inferior quality made on a new principle, the strands being wrapped in an entire covering of wire.

Mr DIXON said there was one point in connection with the ropes: he noticed that they were very large ropes—four inches in circumference, which was fully an inch and a quarter in diameter. If one such rope was on an empty hutch, and a considerable distance between the hutches, it would be very apt to be overturned. It was another argument that two ropes were necessary.

Mr GRANT said that there was another important point in regard to haulage in such a place as this: he did not think there was an incline of the same depth where the haulage was done at the same rate and the same quantity was taken over it. The incline would ultimately be driven twice the length, and it would not interfere with the quantity raised. The only additional cost that would be required would be the driving of the incline and an additional length of rope.

Mr THOMAS ARNOTT, in reply to the President, said his experience was with a chain in a steep incline, and he would consider the double rope an improvement on the chain where the gradient was greater than 1 in 6.

Mr TELFER asked if Mr Grant could state whether they lifted the hutches from one place or from branches on the way.

Mr GRANT said that the tubs, as was shewn on the drawing, were all lifted from the one place in the meantime, but, of course, it could easily be arranged to lift at different places.

The PRESIDENT said they had had described to them a system that had been in operation for at least two and a half years. This system had succeeded so far, and so far as he could see,

was admirably arranged. Mr Grant had mentioned in the paper that the two ropes tended to keep the hutch from twisting. They all knew when hutches were attached simply from one side there was a great pressure on the flange of the wheel against the rails, and that tended to increase the friction very much. In this case, the hutch went as if there was one rope going over the centre of it, and so far as he could judge it seemed to him a very admirable arrangement, and he thought where coals were drawn up such a steep inclination as this it would be a very good thing to have.

The PRESIDENT then closed the discussion, and on his motion a hearty vote of thanks was accorded to Mr Grant for the trouble he had been at in preparing the paper.

The following paper on "Scotch Mining Legislation" was then read by Mr Barrowman :—

SCOTCH MINING LEGISLATION.

By JAMES BARROWMAN, Mining Engineer.

THIS paper is designed to provide, in small compass, and in a form as complete as the opportunities of the writer have afforded, a record of the successive steps taken by the legislature of this country to regulate matters relating to minerals and mining in Scotland, from the earliest times till the present day. The particulars as to coal mining are given in more detail than those in reference to other minerals. The Acts of the Parliaments of Scotland, both public and private, and Registers of the Privy Council, so far as printed, supply the information up till the union of the Parliaments in 1707, after which date the legislation relative to Scotland has been got from the public Acts of the Parliaments of Great Britain. Advantage has been taken of information available outside the Acts serving to illustrate matters therein dealt with, and calculated to make the paper more generally interesting.

The earliest notice in the Acts has reference to the precious metals, and is a charter of the mine of Aldeston granted in 1291,* but a grant dated more than a century earlier is recorded elsewhere†.

Records have been preserved of a few cases‡ of coal mining in Scotland in the 12th and 13th centuries, but the earliest Act§ of

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* *Acts of the Parliaments of Scotland*, Vol. i., p. 112. † David I. granted to the Abbey of Dunfermline, in 1153, a tithe of all the gold which should accrue to him from Fife and Fothrif. *Regist. de Dunfermlin*, p. 16. Cochrane-Patrick's *Records of Mining in Scotland*, p. xiii.

‡ In the 12th century, a grant confirmed by King William the Lion, was made to the monks of Holyrood of a tithe of the colliery of Carriden. Chalmers's *Caledonia*, Vol. ii., p. 866.

Between 1210 and 1218, Seyer de Quinci, Earl of Winton, made a gift of a coal work adjoining Pinkie and Inveresk to the monks of "Newbotle."

In 1291, William de Oberwill gave the abbot and monks of Dunfermline the right of opening the coal heugh in the lands of Pittencrief for their own use. These two grants are printed in full, in the original Latin, in Cochrane-Patrick's *Records of Mining in Scotland*, p. 1.

A charter of James, High Steward of Scotland, dated 1284, granted to William de Prestun the lands of Tranent with various privileges, in moris et maresiis in petaris et carbonariis. Chalmers's *Caledonia* Vol. i., p. 793. The same personage granted to the Abbey of Paisley, in 1294, power to quarry stone and lime and dig sea-coal throughout his forest in the Barony of Renfrew. *Reg. de Passelet*, p. 93. Galloway—*Trans. Min. Inst. Scot.*, Vol. vii., p. 167.

§ *Acts Parl. Scot.*, Vol. i., p. 438.

which we have any account is dated 1294, and relates to the sale of coal and other produce at Berwick, alongside the ships importing them. There is no indication as to whether the coal was Scotch or English. It was to be purchased at the ships, and removed only between sunrise and sunset, and without intermission, under a penalty of a cask of wine to be given to the Guild.

The first of the public Acts* referring to the precious metals is dated 1424. It is a model of brevity, and runs as follows :—
"Gif ony myne of golde or silver be fundyn in ony lordis landis
" of the realme and it may be prowyt that thre halfpennys of
" silver may be fynit owt of the punde of leide The lordis of
" parliament consentis that sik myne be the Kingis as is usuale
" in uthir realmys."

The trade in coal appears to have been well established in the country before 1425,† for in that year an Act‡ was passed ordaining the aldermen and bailies in each place and town, where goods were sold by the water measure, to appoint a "lele man sworne" to measure all goods sellable by the water measure, "als wele colis als uther gudis."

A grant was made in 1450§ to the Carthusian monastery of Perth, of lands—"silvis lapide calce carbonibus fabrinis brac . . is cum minuris cujuscumque metalli."

In 1524 a justice ayre was ordered‖ to be held on those who had broken the order of the mine and laboured therein, and had carried gold out of the kingdom.

Parliament in 1526¶ ratified a concession of the mines of gold, silver, and other metals in the kingdom, for 43 years, to Joachim Hechscatter and four others.

In 1535,** a commission was appointed to deliberate about the coinage, and to consult about the mines.

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* *Acts Parl. Scot.*, Vol. ii., p. 5.

† The collieries of Tranent were apparently well known in 1322; Chalmers's *Caledonia*, Vol. ii., p. 400. Coal was worked at Inverkeithing in the time of King David II., 1329-1371; Robertson's *Index to the Charters*, p. 47; and at Dysart in 1406, *Ibid*, p. 163.

‡ *Acts Parl. Scot.*, Vol. ii., p. 10.

§ *Acts Parl. Scot.*, Vol. ii., p. 65.

‖ *Acts Parl. Scot., Sup.* (Vol. xii.,) p. 41.

¶ *Acts Parl. Scot.* Vol. ii., p. 310.

** *Acts Parl. Scot.*, Vol. ii., p. 343.

In some of the Acts, passing references are made to coal, which, although not of public importance, may be quoted, as they give glimpses of the state of the coal industry at times regarding which little information is now to be had.* Such a reference occurs in a petition† presented to Parliament in 1542, where it is stated that the "colehewis" of Wallyfurd and Preston belonging to the Crown were worth 1100 merks yearly.

The Privy Council in 1562‡ granted licence to John Achisone and John Aslowane to "wirk and wyn the leid mynis of Glengoner and Wenlok," on payment of 45 ounces of silver for every thousand stones weight of lead ore. They worked these mines till 1565, when licence was granted§ to the Earl of Athole to win forty thousand stones of lead ore, "within the nether lead hole of Glengonar and Wanlock," he paying fifty ounces of silver for every thousand stones weight. In the same year, James Carmichael and two others, burgesses of Edinburgh, were granted licence‖ for ten years to win forty thousand stones

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* Apart from the Acts the following particulars have been preserved:—Coal was sought for in Kintyre in 1498. *Accounts of Lord High Treasurer*, Vol. i., p. 388.

Coal was worked in the burrow lands of Tarbolton in 1497. Chalmers's *Caledonia*, Vol. iii., p. 447.

The coal of Culross was subject to tithe rent in 1510, also the coal of Sauchie, in Clackmannan. *Chart. of Cambuskenneth*; Chalmers's *Caledonia*, Vol. i., p. 793.

In 1526, Hector Boece wrote: "In Fiffe ar won black stanis quilk has sa intollerable heit quhair thay are kendillit that they resolve and meltis irne and ar thairfore richt proffitable for operation of smithis. This kind of black stanis are won in na part of Albion bot allatlie betwix Tay and Tyne."—Bellenden's *Boece, Edin.*, 1821, p. xxxvi.

An agreement between the convents of Newbattle and Dunfermline in 1531, regarding the working of coal near Pinkie, gives some insight into the methods of working of those times. The agreement is printed in full in Cochrane-Patrick's *Records of Mining*, p. 2. These coal workings afforded refuge to the people of the district at the battle of Pinkie in 1547.—Galloway—*Trans. Min. Inst. Scot.*, Vol. vii., p. 169.

Coal was discovered at Brora, in Sutherlandshire, before 1567.—Chambers's *Domestic Annals*, Vol. i,. p. 301.

In 1555, the tenants of Stentoun got licence to dig for coals on payment to the convent of Dunfermline of the ninth load that came on the coal hill.—*Historical Manuscripts Commission*, fourth report, p. 499.

Coal at Gladsmuir was leased by the Magistrates of Haddington in 1572.—*Copy lease in the writer's possession.*

† *Acts Parl. Scot.*, Vol. ii., p. 424.

‡ *Reg. Priv. Coun.*, Vol. i., p. 232.

§ *Ibid*, p. 373.

‖ *Reg. Sec. Con.*, Vol. i., p. 400.

weight of lead out of any ground within the realm, saving the work and mine of Glengonar and Wenlock.

In 1563, an Act* was passed prohibiting export of coal, except so much as was needful for fire during the time of the voyage, on pain of confiscation of the ship and all its contents. The fear of exhaustion of coal in the country was the occasion of the passing of this Act, the preamble of which is as follows:—"Our Soverane Lady and Estatis foirsaidis havand "considerationn of the greit multitude of coillis continuallie "caryit furth of this Realme not onlie be strangearis bot alswa "be the liegis and inhabitantis of the samin quhilk is now "becummin the commoun ballast of emptie Schippis and gevis "occasioun of maist exhorbitant derth and scantnes of fewall "within the samin."

Two years later† the Privy Council, having had a representation made to them that the exporting of smithy coal‡ could not be against the common weal, recommended that the Act prohibiting export should be dispensed with in the case of smithy coal until Parliament should meet, when it could be determined whether the Act should be altered or not. The recommendation does not appear to have been ratified by Parliament; but it seems to have been carried into effect, as we find from an Act of later date that coals were being exported in large quantities, under the name of smithy coal.

In the same year, the Privy Council granted licence§ for nine years to John Stewart of Tarlair, and his son, of "all and sindry "the minis of metall that ar betwix the watter of Tay and the "sherefdome of Orkney," on payment of a tenth part of "every "ure and metall that thai sall happen to win," two years being allowed free of royalty on account of "thair inventioun and greit "chargeis." Liberty to work coal was also granted in the following terms:—"And last of all, gif it sall fortoun the saidis "Johnne and William to find in the outseiking of mynis ony "coilheuchis the Queens Majestie in that caise givis thame fre

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Acts Parl. Scot., Vol. ii., p. 543.

† *Reg. Priv. Coun.*, Vol. i., p. 340.

‡ Probably the small or dross of common coal. See excerpt from Act, 1644, p. 46.

§ *Reg. Priv. Coun.*, Vol. i., p. 330.

"licence to use and occupy the same provyding thai be nocht "within ten mylis of ony of hir Hienes dwelling places, and the "said licence to indure sa lang and upoun the conditioun that "the mynis ar granted unto thame that is to say thai sall pay "the tent part fre to the Queens Grace."

It will be observed that the Privy Council made a distinction between "mynis" and "coilheuchis," the former term being restricted to metals or ores, or the workings thereof. This distinction is observed in all the Scotch Acts, the general description of mines or minerals in no case including coal.

There was "sett grantit and disponit" to Cornelius de Vois, for 19 years from 1567,* "the haill silver and goldin myndis and "mynerallis within the realme of Scotland," he paying eight ounces for every hundred ounces purified by washing, and four ounces for every hundred ounces purified by fire. It was also provided that "gif ony vane of leid tin copper or uther mettall "beis fundin on seking out of the saidis goldin and silver myndis "it sall be lesum to the said Cornelius and his foirsaidis to win "the samyn payand to oure soverane lord and his successouris "siclyke proffeittis and to sic nowmer as utheris his hienes liegis "payis presentlie for the lyk."

The apprehension of the exhaustion of coal in the country, fostered, perhaps, as much by the unsettled state of the times as by the inadequacy of the primitive appliances used in mining, was widespread, and appears in almost every Act until towards the end of the seventeenth century. Salt making was an important industry in Scotland in those times, and a large quantity of small coal was consumed in its manufacture. The masters of the salt pans made complaint in 1574† of the dearth of coal for salt making.

In an Act as to coinage in 1574‡, reference is made to gold of the King's mines.

On the expiry of the lease of the mines of Glengonar to the Earl of Athole, permission was given George Douglas of Park-

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* *Reg. Priv. Coun.*, Vol. i., p. 612.
† *Acts Parl. Scot.*, Vol. iii., App., p. 93.
‡ *Acts Parl. Scot.*, Vol. iii., p. 94.

head* to work them, on payment of fifty ounces of silver for every thousand stones weight. And in 1576, Abraham Peterson got a licence† for twelve years to work gold, silver, and lead mines in Scotland, excepting the lead mines in Glengonar and Orkney granted to George Douglas and others, on paying six ounces out of every hundred of gold or silver.

In 1579, an Act‡ was passed ratifying that of 1563, and ordaining the same to be put in execution in all points, with this addition, that "the revelair and apprehendair of the contra-"venaris" of the said Act was to have a third part of the escheat. No notice is taken in this Act of the recommendation of the Privy Council of 1565, nor exception made in favour of smithy coal.

A grant of lead mines to the Earl of Arran was ratified in 1584.§

Eustachius Rooch, a person evidently of some note as a mining adventurer and an inventor, was, in 1584, granted a licence‖ for 21 years, to work gold, silver, copper, tin, and lead mines and minerals within the realm of Scotland, without prejudice to the rights of the Earl of Arran to certain lead mines. He was also allowed to work coal, the grant being in the following words:—"As alsua gif "it happinis the said Eustachius to win onie coll in seiking furth of "the saidis myndis to tak thereof sa mekle for fyning and melting "of the saidis mettellis as sal happin to be fynit and meltit. As "alsua to cut win and leid away pettis out of ony his hienes "mosses and moris nixt adjacent to the samin Providing that "he na wayis sett onie of the saidis wod coill or peitt to any "merchand he pleises bot use the samin to the use foirsaid. . . " . . . and gif he salhappin to searche and find out the "myndis neir to thai pairtis quhairunto the timmer fewall "peittis or coill may not easilie be cariit out of the forrestis "mosses or pottis pertening to his hienes for fyning of the "metallis in that cais it salbe lesum to him to carie tak away

* Cochrane-Patrick's *Records of Mining*, p. xxxv.
† *Reg. Sec. Con.*, 1575—7, fol. 23.
‡ *Acts Parl. Scot.*, Vol. iii., p. 147.
§ *Acts Parl. Scot.*, Vol. iii., p. 356.
‖ *Acts Parl. Scot.*, Vol. iii., p. 369—371.

"and transport the ure of thai places unto quhatsumevir pairtis "beyond sea quhair he may have the best commoditie of fyre "and timmer for fyning of the samin."

In the same year reference is made in an Act* to "Lord "Sinclairs coil pot at Dysert."

The Acts passed to prohibit export of coal, already referred to, appear to have been to a great extent a dead letter, and coal was being largely exported to England under the name of Smithy coal. In an Act, dated 1585,† the state of matters is attributed partly to the "iniquitie of the tyme," and partly to the negligence of the authorities; and finding that the practice was increasing "to the fostering of derth and grete hurte of the "commonweil," proclamation was ordered to be made of the existing Acts prohibiting export of coal and other commodities, and the prohibition renewed, under pain of confiscation of the ships and their contents, the transporters and owners of the goods being also liable to punishment in their persons and goods.

The workings of these early times must have been chiefly by opencast or ingoing mines on the outcrops; and the setting on fire of the coal, either by accident or of design, would be an easy matter. This form of outrage by evil disposed persons appears to have been common, for an Act,‡ declaring the "wilful setting "of fire in coilheuchis" to be treason, was passed in 1592.

The Act of 1424 had the effect of checking rather than encouraging the development of the precious metals. To remedy this state of matters, an Act§ was passed in 1592, modifying the former statute. It is of considerable length. In the preamble it is stated that the mines and metals for a long time had yielded no revenue. They had been let to foreigners at a small duty, who had not worked, nor searched, nor taught any natives,

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* *Acts Parl. Scot.*, Vol. iii., p. 322.

† *Acts Parl. Scot.*, Vol. iii., p. 426.

‡ *Acts Parl. Scot.*, Vol. iii., p. 575. A conviction under this Act is recorded. John Henry, a miner in Little Fawside, set fire to the coal heugh of Fawside, belonging to Mungo McCall, out of ill will, because he had "nocht that libertie and commandiment "under him quhilk he had under Johnne Levingstoun his predecessour." Pitcairn's *Criminal Trials*, Vol. iii., p. 361.

§ *Acts Parl. Scot.*, Vol. iii., p. 556.

nor paid the duty; and metals when found had been either neglected or obscured, because no part of the profit was received by the lieges. The Act appointed for life an officer, called the master of the metals. He was to see to the payment of duty by those having power to work the metals. All feu tacks, contracts, and dispositions of metals or minerals were to have his approval. In the event of those to whom the metals were feued refusing or delaying to work them, the master of the metals could cause others to be employed, not exceeding forty in each shire, with power to take moss and wood for their works from the adjacent lands, compensation being made to the landholder for damage sustained by him. The master of the metals was to be accountable to the Royal Treasurer for one tenth part of the metals, being the royalty payable thereon, and his fee was to be one twentieth part of the royalty. The mines and metals formerly annexed to the Crown were then dissolved in the following words. "And als understanding that the dewtie of "the said mynis qlk baith of the common law and consuetude "observit be uther foreign princes properlie pertenis to the "prince extendis onlie to the tent part fre Thairfore our said "soverane lord with avise of his estaittis in parliament hes "dissolvit the saidis mynis and metallis in sa fer as thay war "part of his propirtie annext or ony wyis to the effect the same "may be sett in feu for augmentatioun of oure said soverane "lordis rentall." Any baron or landholder was entitled to get set to him in feu ferme all these minerals which might be found in his own lands, on payment of one tenth part as royalty for what was worked; and in the event of any known mines on any persons lands not being worked by him after notice of three months, they might be set in feu ferme, or otherwise worked, at the King's pleasure. A provision in favour of workmen employed in the mines is in the following terms:—"And be "ressoun the saidis myneris and warkmen is dalie in the hasart "of thair lyves be the evill air of the saidis mynis And the "danger of the falling of the same and uther infinite miseries "and dangearis qlk dalie occurris in the said wark Thairfoir "oure soverane lord with avise foirsaid exemis the saidis "myneris mettallaris and uthers actuallie remanent at the said

"work fra all taxationis chargis proclamationis and uther chargis "quhatsumevir bath in peace and weir."

The general of the cuniehouse protested* against the act of dissolution from the Crown, on the ground that it was "proponit "cum diminutione," the mines having hitherto paid fifty ounces of utter fine silver per thousand stones, which was nearly four times as much as the tenth part agreed on.

In 1594, Thomas Foulis got power† for 21 years to "serch "seik brek the ground wirk win intromett with and ressave "cary fyne refyne and transport to ony pairt of this realme or "outwith the same use and dispone at thair plessour all and "quhatsumevir mettallis and minerrallis alsweil of gold silver "leid tyn and utheris" within the forty pound land, called Freirmure, pertaining of old to the abbacy of Newbotle, lying within the barony of Craufurd Linsay and sheriffdom of Lanark, at a yearly rent of one thousand merks.‡ Foulis's carriers having been robbed while conveying the lead to Edinburgh and other markets, the Privy Council authorised§ them to wear a blazon of lead on their breast, marked with the King's arms and those of Foulis; and any one offering them violence was to be punished with all "rigour and extremitie."

Another Act,‖ prohibiting export of coal, appears in 1597; because notwithstanding former Acts, a large trade was carried on by sea. This Act narrates that "the great burne coillis are "commounlie transportit furthe of this realme be divers and "sindre personis quha at all tymis ladynis their shippis and "utheris veshellis thairwithe and transportis the same at their "plessure usand the samin as ane commoun trede." Offenders were liable to confiscation of the ship and its load.

The need of mechanical means to drain the workings must have been felt at even an early stage in the progress of coal mining. From time to time some appliance for which great things are claimed comes under notice in the legislation of the

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* *Acts Parl. Scot.*, Vol. iii., p. 559.
† *Acts Parl. Scot.*, Vol. iv., p. 84.
‡ *Reg. Sec. Con. Acta.*, Vol. 1591—4, p. 278.
§ *Ibid.*, 1594—98, p. 559.
‖ *Acts Parl. Scot.*, Vol. iv., p. 136.

country. In 1598* Gavin Smyth, an Englishman, and James Acheson, goldsmith to the King, were granted for 21 years a monopoly of the manufacture of "ane artificial ingyne in making "of pompis for raising and forcing of waters in greit abundance "furth of mynes coilheuchis quarrellis dround groundis and "utheris efter divers manners as rak pompis lyke to the cran of "ane croce bow grane pompis with flatis and heinyies or girthis "maid of cordis wod horne or mettall alsua counterpaces or "sweipis for lifting of watteris be the force and labour of menis "handis at tymes necessyr and convenient Quhilkis ingynis "sall ather gang with wind water horses or men for the drawing "up of the water in greit quantitie furth of mynis coilheughis "quarrellis and uther deip grundis quhairby not onlie the water "of gangand coilheuchis mynis or quarrellis may be temit and "made dry bot also ane greit part of the dround and perischet "mynis coilheuchis and quarrellis within this realme may be "recoverit and wyn again."

In the following year a patent was granted† to Eustachius Rooch, already referred to, to improve existing kilns, furnaces, &c. Economy of fuel was claimed as a feature of the invention, which, in the words of the Act, was "to the evident commoditie "and commounweill of the cuntrey and haill subjectis thairof "alsweill in hayning and restraneing of the superfluous spending "of coill wode peittis stray and uther fewall quhilk is alreddie "brocht to ane grit decay within the boundis of this realme by "the excessive spending and consumption thairof."

A number of strongholds with contiguous lands, which had been annexed to the Crown, had becomed ruined and waste, and unprofitable to the King. The King's coalheughs within these properties were unable to be worked without great outlay, so much so that supplies of coal from them had ceased. An Act of 1600‡ empowered the King to set all such lands and coalheughs in "feu ferme heretablie," reserving, however, to Lord Livingstone his right to the coal of Bonnyton, near Linlithgow.

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* *Acts Parl. Scot.*, Vol. iv., p. 176.
† *Acts Parl. Scot.*, Vol. iv., p. 187.
‡ *Acts Parl. Scot.*, Vol. iv., p. 229.

The first Act dealing with colliers is dated 1606.* It prohibits any one from employing any collier, coal-bearer, or salter without a sufficient testimonial from the last employer; and, in the event of their being employed without such testimonial, the master from whom they came had power to claim them within a year and a day, in which case the new employer was bound to deliver up the worker within 24 hours, under a penalty of £100; and such deserting colliers as had received "foirwageis and feis" were to be held as thieves and punished in their bodies. The Act also empowered owners of collieries and salt works to apprehend all vagabonds and sturdy beggars to be put to labour. This measure substantially reduced colliers and bearers to a state of bondage from which they were not quite released for nearly two centuries.

Parliament in 1607† ratified a charter granted to Sir Thomas Hamilton, of Monkland, of the lands and barony of Bynnie, comprehending among others "the coillis, coilheuchis, and all thair pertinentis;" and, with consent of the master of the minerals and metals, of "all and sindrie the mynes, minerallis, and "metallis of gold, silver, brass, copper, leid, and utheris miner-"allis and metallis of whatsumevir sorte, kind, and qualitie," within certain lands in the sheriffdom of Linlithgow. He was also appointed for life to the office of master of the metals and minerals.

The Privy Council gave order in 1607‡ for the digging out of the silver mine lately discovered by Sir Thomas Hamilton of Bynnie, in his estate of Hilderston, a certain quantity of ore, to be transported by sea to London for the better assay thereof.

King James VI. was much exercised in 1609 about the export of coal from Scotland. A petition had been presented by the burghs to the Privy Council in July, 1608, craving a "restraint to be maid of the transporting of burne-coill." But because certain of the lieges had got licence to transport, in consideration of the great "chargeis and expenssis whiche thay haif sustenit and

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* *Acts Parl. Scot.*, Vol. iv., p. 286.
† *Acts Parl. Scot.*, Vol. iv., p. 391.
‡ *Reg. Priv. Coun.*, Vol. viii., pp. 21, 34.

"daylie undirlyis in winning and upholding thair coilheuchis," the Privy Council asked his Majesty's instructions in the matter.*

On 9th January, 1609, the King, writing to the Privy Council,† referred to the Acts of 1563 and 1579 prohibiting export, and ordered that "by oppin proclamatioun, upoun the warrant of that "statute you prohibite and discharge all transporting of sea coill "quhatsomevir to ony pairtis beyond sea."

Consequent on this proclamation, came a petition‡ to the Privy Council from six or seven owners of collieries on the Forth for a mitigation of the restraint. The Council communicated this petition to the King on 30th March, 1609, with the petitioners' reasons, which were as follows :—The water pits had been won and upheld at great expense, some of them having cost 50,000 merks and the poorest of them 300 merks, and others of them, "as Airth, Alloway, Carribdin, and Sawchie," 500 or 600 merks, which could not be borne but by selling to strangers, seeing the whole despatch in the country would not defray half the weekly wages; and any one of the same heughs would do more than furnish the whole towns and parts of the kingdom accustomed to be furnished with sea coal. If the pits were neglected three nights together, which they certainly would if the restraint were not removed, they would "pereishe and drowne "without all possibilitie to be recoverit and wone again," whereby the owners would be undone; the country spoiled of the treasure which exportation yielded; and all men would be "skarrit fra "undirtaking ony suche worke of winning of watter coilheuches "heirefter." They also alleged that they had a huge store of coals on the hills; and on inquiry it was found that some had as many as 10,000 merks' worth on stock. Before sending this communication to his Majesty, the Privy Council had requested§ Archibald Primrois and William Hairt to visit the collieries on the Forth and report "in quhat estate they stand, and yf the "cuntrey dispatche of thair coillis will uphold the same;" and

* *Reg. Priv. Coun.*, Vol. viii., p. 517.
† *Reg. Priv. Coun.*, Vol. viii., p. 547.
‡ *Reg. Priv. Coun.*, Vol. viii., p. 568.
§ *Reg. Priv. Coun.*, Vol. viii., p. 266.

they had reported* that in their opinion the "cuntry dispatche wald not uphald the coilheughis ane moneth."

The King's reply† of 28th April, 1609, states—"We cannot "but marvell either of your grite weaknes kythed in a mater con-"cerning the publict benefite, or then of your cairelesness in pre-"ferring thairunto the privat lucre ather of your selffis or "friendis." After giving reasons why the restraint should not be removed—the most important being that the revenue of the country suffered, as the duty on exported coal from Scotland was less than from Newcastle, and therefore exporters preferred Scotland —the letter concludes with a postscript, written with the king's own hand, as follows:—"It is a shamefull thing that the privat "gayne of some two or three persons sould be putt in ballance "not onlie with the weele of that whole kingdom bot evin of "this whole yle, and I wonder how any doubt can be maid of "the venting of thair coillis since coillis ar at this instant "almost unbuyable for dearthe."

These proceedings were followed by an Act‡ in the same year which ratified those of 1563 and 1599 against exporting coal, but expressly allowed coal to be shipped to England, and stipulated for the collectors of the customs taking a bond from those who shipped to England in surety of their returning a certificate that the coal had been really landed in that country.

Another Act of 1609§ recites that certain veins of rich metal had been discovered in the Highlands, and also certain woods, which, by reason of the savageness of the inhabitants thereabout, were either unknown or unused, and that some parties, taking advantage of the peaceful times, were disposed to erect iron mills in those parts; but the Act proceeds to command "all and "sindrie his majesteis leigis and subjectis that nane of thame "performe nor tak upoun hand to woork and mak ony irne with "wod or tymmer undir the pane of confiscatioun of the haill yrne "that salbe maid with the said tymmer to his majesteis use."

The expectations formed of the superior ability of foreigners

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*Reg. Priv. Coun., Vol. viii., p. 269.
†Reg. Priv. Coun., Vol. viii., p. 575.
‡Acts Parl. Scot., Vol. iv., p. 408.
§ Acts Parl. Scot., Vol. iv., p. 408.

in working the mines formerly annexed to the crown had not been realized; and for many years previous to 1612 the mines had been neglected. In that year the Privy Council issued an order* that the Act of 1592 was to be put in force, and proprietors were to work the mines in their lands, paying the royalty specified by that Act.

Archibald Primrose, clerk of the king's mines, was authorised by an Act dated 1612† to make iron within the Sheriffdom of Perth.

In the same year, Sir George Hay of Nethirliff was granted‡ for 31 years, the privilege of making iron and glass in the kingdom; but nothing is stated as to the source of supply.

The Privy Council made proclamation in 1613§ against the transportation of iron ore. This appears to have been done on the representation of certain persons who had established an iron work somewhere in the country, but could not get sufficient ore to carry it on.

In 1613 the king, by authority of the Privy Council, granted‖ in feu to Sir William Alexander of Menstrie and others the silver mines of Hilderston, in Linlithgowshire. In anticipation of a large number of persons being employed at the mines, a commission was appointed¶ in the following year "to mak preseryve "and set doun actis and ordinanceis for retening of all these who "ar or salbe imployit in ony kind of chairge service or attend-"ance about the saidis mynis and workis in a peciable and civile "conversatioun ilkane with utheris and with the countrey people "dwelland thairabout," with power to appoint punishment according to the quality of the offence; to impose fines, withhold wages, suspend or depose from employment; or punish by scourging, laying in the stocks, or long imprisonment; and to commit to court those guilty of stealing or resetting, or other serious crime punishable "by lyff or member."

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* *Acts Parl. Scot.*, Vol. iv., p. 391.
† *Acts Parl. Scot.*, Vol. iv., p. 515.
‡ *Ibid.*
§ *Reg. Sec. Con.*, Oct. 1612–Nov. 1614, p. 166. Cochrane-Patrick's *Records of Mining*, p. 162.
‖ *Reg. Sec. Con.*, Oct. 1612–Nov. 1614, p. 161. Cochrane-Patrick's *Records of Mining*, p. 159.
¶ *Ibid*, p. 226. ¶ *Ibid*, p. 163.

By Act of Privy Council in 1616,* Stevin Atkinsoun was granted liberty to work gold and silver in Crawford Moor, on payment of a tenth part to the Crown. His efforts do not appear to have been fruitful, as we find that the gold in Crawford Moor and other lands in the district was let to Doctor Hendlie† in 1621 for 21 years, on payment of a tenth.

Parliament in 1617‡ authorised justices at their quarter sessions in August and February to appoint the ordinary hire and wages of labourers, workmen, and servants, who, if refusing to serve upon the prices set down, should be imprisoned and further punished at their discretion. Reference is made to this Act here, because a later Act § held this measure, and a similar one of 1661, to be applicable to colliers and other colliery workers.

In 1621 the Privy Council fixed the price of coal at seven shillings the load ; ‖ but on a representation made by the proprietors of Elphinston, Smeaton, Pencaitland, Fawside, and Whitehill, of the great expense they were at in working their coal, the price was raised by the Privy Council to seven shillings and eightpence per load.

In 1621 Parliament appointed a Commission ¶ to examine into the condition of all the coal works lying within two miles of the water of Forth,** and the coast on both sides of the same, with the view of ascertaining if the coalheughs were difficult to win and in danger of drowning if not speedily worked, and whether the demand in the country and towards Leith was sufficient to carry them on profitably, "that it might be the more perfectly "known if the restraint of exporting of coal be necessary or not." The Commission was instructed to report to the Lords of Council in the following January, but it does not appear that this was

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* Cochrane-Patrick's *Records of Mining*, p. 166.

† *Ibid*, p. 169.

‡ *Acts Parl. Scot.*, Vol. iv., p. 537.

§ 39 Geo. III., chap. 56.

‖ *Reg. Sec. Coun. Act*, March 1, 1621.

¶ *Acts Parl. Scot.*, Vol. iv., p. 630.

** In 1617 the workings of Culross Colliery extended under the Forth, and were connected with a pit on an island. King James VI. is said to have visited this colliery, and been brought to the surface at the island, much to his surprise.—Chambers's *Domestic Annals*, Vol. i., p. 485.

done. The reference to export in this Commission is an indication that the Acts against export had been felt to be irksome; and we have seen that they were to a great extent ignored. Probably they were the means of checking enterprise; and they delayed the profitable development of the great coal fields whose fringes merely had as yet been touched.

The next article of legislation, which is dated 1625,* and deals with custom on coal, assumes the existence of a large export trade.† It states that previous to that time export had been entirely carried on by strangers, and it imposes a custom of forty-eight shillings Scots per ton on coals transported in stranger bottoms, which, as it proceeds to state, "is far less than they pay "here in England, neither will we ony longer suffer that shameful "abuse whairby for the filthie gain of a few the whole "kingdome is wronged, and strangearis preferred to our national "subjectis." This impost was regarded by the coal owners on the Forth as very prejudicial to their interests. They represented‡ to Parliament that the charges for draining their mines were so great that the country sale and local despatch of their coal were quite inadequate to give them a return for their outlay, and that they could not uphold their works without shipment by strangers, because the number of native vessels was too few for the trade. The imposing of the custom would, they said, divert the shipping away from the Scotch collieries, and cause the stopping of many of them, "not only to the utter undoing of the awneris bot to "the extreame hurt and prejudice of the cuntrey, whilk by this "occasion will be destitute of all the sea coale within the "kingdom, besydes the miserable wraik of money hundreth "families of poore people whose onlie mantenance dependis "upoun thir workis, and without the whilk they will be all "turnit beggaris." The matter was represented in the same year by the Privy Council to the King,§ and the impost appears to have been departed from.

* *Acts Parl. Scot.*, Vol. v., p. 176.

† In a letter from the Marquis of Hamilton to King Charles I., dated 27th November 1638, it is stated that the chiefest trade of the burghs "is in the eastern seas and in "Holland, with coal and salt and importing of victual and other commodities from "thence."—*Hamilton Papers.*

‡ *Acts Parl. Scot.*, Vol. v., p. 181.

§ *Acts Parl. Scot.*, Vol. v., p. 186.

The gold and silver in the lands of Crawfordjohn were let by Charles I. in 1631 to James, Marquis of Hamilton and others for seven years.*

A gift of minerals was ratified in 1639† to the Marquis of Hamilton and James Maxwell, but the Act gives no particulars.

Parliament had before it in 1639 a petition‡ from the coal-masters craving a discharge of the custom upon coal unwarrantably exacted by the conservator. Particulars are not furnished, but the petition was sustained, and an Act § passed discharging the conservator's exactions, against which Act he protested.||

There is no doubt coal was worked to a considerable extent at this period in the west¶ as well as in the east of Scotland, although legislation was primarily directed to the trade connected with the works in Fife and the Lothians. The first reference to coal workings in the west which the Acts yield is in a petition** by the laird of Craigie Wallace against the town of Ayr for restitution of the house of Newton and goods taken from him during the troubles of preceding years, and satisfaction for damage and interest of his coal and salt pans. The latter claim was remitted to be considered.

An Act of 1641†† ratified that of 1606 as to coal hewers and salters, with the addition that because watermen who lave and draw the water in the coal heughs, and gatesmen who work the ways and passages, are as necessary to the owners and masters of the said coal heughs as colliers and bearers, no person should hire or seduce any waterman, windsman, or gatesman, without a testimonial of the master whom they serve. The system of giving fees or bounty appears to have been extensively practised, probably by those who were opening up new coal works, as an inducement to colliers to attach themselves thereto. In this Act

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* Cochrane-Patrick's *Records of Mining*, p. xxi.

† *Acts Parl. Scot.*, Vol. v., p. 600.

‡ *Acts Parl. Scot.*, Vol. v., pp. 601, 602, 266.

§ Ibid, 603. || Ibid, 614.

¶ Coal was worked to a small extent near Hamilton in 1645, and supplies for Hamilton Palace were got from Newarthill also at that date.—*Hamilton Papers.*

** *Acts Parl. Scot.*, Vol. v., pp. 600, 602.

†† *Acts Parl Scot.*, Vol., v. p. 419.

it was ordained that "it sall not be lawfull to ony coilmaisteris "in this Kingdom to give any greatter fie nor the soume of "twentie merks in fie or bounteth under any cullour or pretext."

The social habits of the miners* and their practice in the matter of idle days are first referred to in this Act, and are made the subject of legislation in the following terms:—"And Becaus the "saidis coilhewaris and salteris and utheris workmen in coil-"hewghis within this Kingdom dois ly from thaire work at "pasche yoole and witsonday and certane uther tymes in the "yeare quhilk tymes they imploy in drinking and deboshrie to "the great offence of God and prejudice of their maisteris It is "thairfore statute and ordaneit that the said coilhewaris and sal-"teris and utheris workmen of coilhewghis in this Kingdom worke "all the sext dayeis of the weik under the paines following "That is to say that everie coilhewar or salter quho lyis ydle sall "pay twentie shillingis for everie day by and attour the preju-"dice sustainit thaire maisteris and uther punishment of thaire "bodies."

Another Act of 1641† ratified to John Earl of Tarquair "all and haill the minerales of gold silver copper leid airne tyn "and uther minerales quhatsumevir" within certain lands in Peeblesshire.

A grant was made to Sir Thomas Hope in 1644 ‡ of the lands of Waterhead "and of the haill mynes of gold silver copper tin "leid and otheris mineralis quhatesomevir," he paying to the crown a tenth of the ore won, or 1000 merks yearly.

A list of commodities subject to excise is given in an Act § dated 1644, and includes coal. The duty was six shillings on coal exported in Scotch or English bottoms of the value of twelve pounds; and twelve shillings on coal of the same value exported in foreign bottoms.

In the same year || Parliament ratified the Acts and decrees of the Privy Council in favour of royal burghs of 1620, 1621, and

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* Some interesting matters concerning the customs of the colliers and their relations with their masters are described in Grossart's *History of Shotts*, p. 239.

† *Acts Parl. Scot.*, Vol. v., p. 463.

‡ *Acts Parl. Scot.*, Vol. vi., part 1, p. 270.

§ *Acts Parl. Scot.*, Vol. vi., part 1, pp. 76, 77, and 238.

|| *Acts Parl. Scot.*, Vol. vi., part 1, p. 177.

1643, regulating the prices of coal, and ordained coalmasters to supply natives with coal in preference to foreigners. It extended the scope of these Acts to all natives and dwellers within the kingdom, and ordained "the whole coalmasters within this king-"dom to readily answer and obey all the natives of this king-"dom as they, their coalgreeves, or coalyars, shall be desired "from time to time, not only with great burning coales for use of "their houses and brewing, but also with small coales for burning "of lyme, serving of their smiddies, or any other use needful, and "that at such prices and with such measures as the said coal-"masters coalgrieves and coalyars has been in use to sell the "samine these seven years bygone." Commissioners were appointed to visit the harbours where coals were exported, and see to the carrying out of the Act and the punishing of contraveners. The Earl of Dunfermline's coal "of the Crocegaites of "the Mure of Dunfermline" was excepted from the Act until 25th December, 1646.

In that year also an order* was made that the coalmasters or their coal-grieves were to keep a book, in which was to be entered the just price of coals shipped, which book was to be sent to the collector of customs once a month, in order that the excise payable on the coal might be computed and paid.

A petition† was presented to Parliament in 1645 by John Earl of Wemyss, Alexander Lord Elphingstone, and Sir Alexander Shaw of Sauchie, for themselves and in name of the other coal and salt masters in the kingdom, complaining of the valuation of the rental of their works, and upon which they were taxed for maintenance of the army, and representing that it should not be upheld. The valuation had been made when Newcastle trade was barred, and the Scotch collieries had in consequence been very busy; and the trade had now collapsed. The arguments in support of the petition were as follows:—"It being now manifest "that there is no trade nor traffic neither without nor within the "Kingdom for pirates on the seas and for sickness within the "lands (where chiefly our countrie sale was most) and so con-

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* *Acts Parl. Scot.*, Vol. vi., part 1, p. 242.
† *Acts Parl. Scot.*, Vol. vi., part 1, pp. 447, 448.

"sequently we have no rent and therefore cannot pay taxt nor "mentenance but our workmen employed for the most part as "soldiers in the service of the Kingdom we not being able to "entertaine the remanent of our workmen who are at home being "old men unable to carie arms and far more unable to work their "work to make us benefit without the assistance of the young "men who is presently in the service nor yet to defray the great "costs and hazards our works are liable to."

The prayer of the petition was granted, and a revaluation of the rents ordered to be made. A similar petition* the following year was dealt with in the same manner.

By an arrangement with the English Parliament made sometime before 1645, a number of men had been employed at Newcastle for the working of coals there for the maintenance of the army. These men being still employed in 1645 was the occasion of correspondence† between the Parliaments in that year.

A ratification‡ of a charter in favour of James Allan of Stakis appears in the statutes in 1646. The portion relative to coal is as follows :—"The estates of Parliament . . . ratifies . . . "ane charter . . . . in favour of James Allan. . . . "of all and sundrie coillis coalheuchis alsewell great as small "win or to be win alsewell within as without the sea flood before "the lands of Stakes and pertinents thereof lyand within the "barronie of Carridin and sheriffdom of Linlithgow, with full "power to the said James Allan and his foresaids to win the said "coals and coaleheuchis and to brek any part of the ground of "the said lands of Stakes, as well within as without the sea flood "before the said lands, and to make coalheuchis and other necessyr "ingynes for wyning and transporting of the saidis coalis to sea "and land and to make frie gaittis and passages to that effect "and to dispone upon the said coales win or to be win at their "pleasure, with free ische and entrie of wayis and passages for "winning, careing, and transporting of the saidis coalis either by "sea or land."

Acts Parl. Scot., Vol. vi., part 1, p. 535.
†*Acts Parl. Scot.*, Vol. vi., part 1, p. 323.
‡*Acts Parl. Scot.*, Vol. vi., part 1, p. 606.

In 1646,* Sir James Hope craved revaluation of the lead mines; and the matter was remitted to the Committee of Estates of the Sheriffdom of Lanark.

The colliers' usual flitting day was Christmas, and it would appear that the festivities observed at their entry to a new work at that season were regarded by some as a superstitious observance of the day. Accordingly the following Act was passed in 1647.†

"The estates of Parliament, considering that the observing of "Yule day and other superstitious dayes is much occasioned by "coal-hewers and salters flitting and entrie at Yule: therefore "they ordain that the terms of flitting and entry of all coal-"hewers and salters shall hereafter be upon the first of Decem-"ber, yearly discharging any entry or removal to be at Yule or "any other superstitious days, in any manner of way, and that "under the pains contained in the Acts of Parliament made "against prophanation of the Sabbath: and recommends to all "whom it concerns to see this Act observed and the contra-"veeners punished in their persons and goods condignly."

The powers conferred on the master of the metals by the Act of 1592 appear to have been to some extent abused, and damage done by tacksmen of the King's mines and minerals to the lands in which they were situated, without compensation having been made to the landowners; the consequence being that they were unwilling to make known the existence of minerals in their lands. To remedy this state of matters, and for securing the lieges of their property, and increasing the wealth of the kingdom, it was enacted in 1649‡ that the master of the metals would not be at liberty to grant tacks to open up any ground for minerals until the heritor thereof was heard as to the probability of minerals being found; and if such were found, the heritor was to be preferred, he providing caution to use diligence within three years thereafter for searching and working the minerals; and paying therefor to the master of the metals a tenth part of all ore and metals found; and failing the heritor's working, asking preference, finding caution, or doing diligence,

* *Acts Parl. Scot.*, Vol. vi., part 1, p. 602.
† *Acts Parl. Scot.*, Vol. vi., part 1, p. 761.
‡ *Acts Parl. Scot.*, Vol. vi., part 2, p. 382.

the master of the metals, or those having warrant from him, was to have power to search, win and dispose of the said metals and minerals, the heritor to be paid for all damage sustained by him through the breaking and spoiling of the ground in the searching, winning and working of the minerals. Former Acts inconsistent with this Act were rescinded; and, for the more effectual searching for and working of minerals, heritors were encouraged to bring foreigners skilled in mining, who should have the privileges and immunities, specially from watching and warding, granted in former Acts. It was further declared that "all "heritors *eo ipso* that they have right to any lands they have "In all time coming shall have right to all and whatsomever "mineral within the said lands without the necessity of taking "special and particular infeftments, paying and doing diligence, "as is aforesaid."

Protests* in connection with this Act were made by the Earl of Haddington; and by the Marquis of Argyll and the Earl of Cassillis in name of the whole heritors in the kingdom.

In 1649, Sir James Hope petitioned Parliament that the privileges introduced in favour of masters of coalheughs and saltpans be "also extendit in all tyme heirefter in favours of "masters and prosequteris of mynis," and an Act† was passed in that year declaring "all Acts of Parliament and privileges therein "contenit maid and introducit in favouris of masteris of coil-"heughis and saltpanis to be now and in all tyme coming "extended to and in favouris of the said Sir James Hope and his "successoris, prosequtoris of the said work, and uther mynes within "the boundis foirsaidis." The privilege was also extended "to "and in favouris of all other myneris who sall intent and pro-"sequte the lyke workis in any time heirefter."

In the same year‡ ratification was also made by Parliament in favour of Sir James Hope, and his works, and workmen, of the exemption from "all quartering watching warding levies of "horses and foot mentinance excyse and uther publict burdins in "all tyme heirefter."

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* *Acts Parl. Scot.*, Vol. vi., part 2, p. 208.
† *Acts Parl. Scot.*, Vol. vi., part 2, p. 359.
‡ *Acts Parl. Scot.*, Vol. vi., part 2, p. 584.

A valuation of the rents of the "coal hews" in the shire of Clackmannan was ordered in 1649.*

In the same year an Act was passed† for providing meal and coals to the castles of Edinburgh, Stirling, Dumbarton, and St. Johnstoune (Perth). The coals to be supplied were:—the quantity formerly appointed for the garrison of Stirling, and 500 loads more; 1000 loads for Edinburgh, and 100 chalders from Lord Sinclair's "coalpottis" for St. Johnstoune, each chalder being 32 loads. In the following year Lord Sinclair's ‡ factor was ordered to furnish 1000 loads of coal for Edinburgh castle, the bailies of Dysart to transport them to Leith.

In 1651, a committee was appointed § to "conferre with the "proposers concerning the mine in Scotland," and to report thereon to the Council.

A proposition delivered to the Council in 1652 || by Mr Scot concerning the discovery of gold in Scotland was referred to the consideration of the committee for mines.

It is noted in the Acts in 1656,¶ that the "humble petition of "Sir James Hope for himselfe and in the name of the many "poore workers about his mynes at the Leadhill in Scotland," be referred to the committee of the Council for the affairs of Scotland.

The statute of 1644, obliging coalmasters in selling their coals to prefer natives to strangers, apparently fell into disuse through want of the re-appointment of commissioners to see to its provisions being carried out. In 1656 the free burghs made application** for the Commission to be renewed. Parliament had found "the coalmasters and others having interest in the coalheughes in "the nation taking a boundless and arbitrary liberty to sell their "coals contrary to the said Acts of Council and Parliament to "the heavy prejudice of the poor people in this nation;" and appointed commissioners, defined their duties, and fixed the price

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* *Acts Parl. Scot.* Vol. vi., part 2, p. 452.
† *Acts Parl. Scot.*, Vol. vi., part 2, p. 475.
‡ *Acts Parl. Scot.*, Vol. vi., part 2, p. 590.
§ *Acts Parl. Scot.*, Vol. vi., part 2, p. 746.
|| *Acts Parl. Scot.*, Vol. vi., part 2, p. 748.
¶ *Acts Parl. Scot.*, Vol. vi., part 2, p. 762.
** *Acts Parl. Scot.*, Vol. vi., part 2, p. 846.

of coals at the rate which had ruled for seven years prior to 1644.

Another Act in 1656* ordained that all Scotch coals exported in vessels belonging to the people be valued at four shillings a ton, and the like coals exported in vessels belonging to foreigners at eight shillings a ton ; and that the custom and subsidy thereof be levied and received according to the said rates.

A customs return† for the year 1658, gives the custom of coal in Scotland, farmed to Mr Noell at £2216 5s 4d.

An Act dated 1661,‡ ordained that all commodities exported after that date were to be liable to the mint in certain proportions of bullion therein stated. Coals were to bear the proportion of two ounces of silver for every four chalders of coal.

The Act of 1641 as to coal-hewers, bearers, gatesmen, etc., was repeated in 1661 in precisely the same words.§

A monopoly for nineteen years was granted in 1661 || to Ludovick Leslie and James Scot, of the making of iron with coal, and the raising of water and weights out of pits, and other inventions.

An Act of 1661¶ set forth that it would tend to the King's honour and profit that the "mynes with which the kingdom so "much abounds" be effectually prosecuted, and ratified to Sir James Hope of Hopetoun the privileges granted in favour of miners in the Act of 1592, and other exemptions granted to Sir James Hope's predecessors; extended the same to the mines and works of Crawford Mure, Binnie and Aithray; relieved the workmen of all public burdens in all tyme thereafter, and extended to Sir James Hope the benefit of the Act in favour of the masters of "Colheughs and Saltpans."

A petition** was presented in 1661 by Sir Ludovick Stewart of Minto to the Lords Commissioners of Bills, representing that some of his colliers had left his coal-work at Nobelferme, near Rutherglen, and praying the Commissioners to

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* *Acts Parl. Scot.*, Vol. vi., part 2, p. 857.
† *Acts Parl. Scot.*, Vol. vi., part 2, p. 785.
‡ *Acts Parl. Scot.*, Vol. vii., p. 252.
§ *Acts Parl. Scot.*, Vol. vii., p. 304.
|| *Acts Parl. Scot.*, Vol. vii., p. 47.
¶ *Acts Parl. Scot.*, Vol. vii., p. 361.
** *Acts Parl. Scot.*, Vol. vii., App. p. 30.

authorise the magistrates of Rutherglen "to take the forsaids "coaliers and uther workers in the said coalhough acted for their "faithful and dewtifull service therein, and that they no more "wilfully divert themselves therefra without licence." The petition was granted.

In the same year, James Bell, a merchant in Glasgow, who owned property adjoining the lands of Gorbals belonging to the town of Glasgow, represented to Parliament* that one Patrick Bryce, who leased the coal in Gorbals from the magistrates, had made an encroachment on his coal and refused to allow an inspection to be made of the alleged encroachment, in spite of the desire of the magistrates that this should be done, threatening to cut the cords if any one went down. Knowing that the petitioner had no recourse at law, Bryce had worked for sixteen months beyond bounds, and then flooded the works; and Bell asked for the appointment of a Commission to take evidence, so that the offender might be punished and reparation made for the loss sustained, which he alleged to be more than 10,000 merks † A Commission was appointed to take evidence in the case and report to Parliament.

The measure by which the custom of coal was fixed had been the subject of much debate between buyers and sellers of coal and the receivers of the customs, as the weight of the chalder, load, or other measure varied in different places. In 1663,‡ Parliament fixed the Culross chalder as being the particular chalder on which the custom on coal was to be imposed.§

The following ratifications appear in the Acts in 1663:—To the Earls of Crawford and Lauderdale,|| of a gift for 19 years of "all mynes, metalls, and mineralls of gold, silver, tin, copper, "lead, and all other mynes and mettalls whatsomever" belonging to the King in the lands of Braid, Woodheid, Brighouse, Newtoun, Logie, and Alva.

**Acts Parl. Scot.*, Vol. vii., App. p. 31.

†In this petition reference is also made to an encroachment case between Wm. Wilkie, of Hagghill, and Alex. Wardrope, of Carntein.

‡*Acts Parl. Scot.*, Vol. vii., p. 487.

§The River Forth chalder, which was probably the same as the Culross chalder, weighed 25 cwts.—Bald's *View of the Coal Trade of Scotland*, p. 42.

|| *Acts Parl. Scot.*, Vol. vii., p. 524.

To Lord Parbroth and Lindesay of Wauchope,* of "power and "libertie to search out worke and use all and sindrie mynes and other "minerals within the paroche of Sidweik and Cowane."

To Charles Maitland of Haltoun and William Scott of Ardross† of "power and liberty to search out, work, and use all mynes "and mineralls within the sheriffdome of Argyll," to be "wrought "and bruicked be them and their airs, assignayes, and partners, "as long as any minerals can be fund therein."

To Colonels Leslie and Scott,‡ their heirs, assignees, and partners, of "power and libertie to search out, worke, and use all "mynes and mineralls" within the parish of Ebdie in Fife and Coldinghame in Berwick, "to be wrought and brooked be them "and their forsaids als long as any minerals can be fund therin."

In 1669, ratification§ was made in favour of Anna Duchess of Hamilton and her heirs of a charter of the lands in the dukedom, and of the minerals therein as follows:—"All and sindrie mynes "of gold, silver, tin, lead, copper, and other metall whatsomever "within the bounds of the haill lands and otheris above-written, "with the privilege and liberty of winning, working, fyning, "refyning, and transporting thairof."

Parliament in 1672‖ ratified a charter in favour of William and Anna, Duke and Duchess of Hamilton, of the lands of Kinglass in Linlithgowshire, with "coalls, coalhewghs, coalwarkes," and others, with the gift of all mines of gold and silver, tin, lead, copper, being or that should happen to be within the bounds of these lands and of the lands and barony of Drumsargate, in the parish of Cambuslang, "with the power of working and winning thereof, and of fyning and refyning, and of transporting the same over sea (gold and silver being excepted)."

A ratification of a charter in favour of Sir John Aytoun, yr., of the lands and barony of Aytoun in Fife, dated 1672,¶ includes "all and sundry the coalls and coallhewghes wone and to be "winne."

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* *Acts Parl. Scot.*, Vol. vii., p. 525.
† *Acts Parl. Scot.*, Vol. vii., p. 525.
‡ *Acts Parl. Scot.*, Vol. vii., p. 525.
§ *Acts Parl. Scot.*, Vol. vii., p. 579.
‖ *Acts Parl. Scot.*, Vol. viii., p. 111.
¶ *Acts Parl. Scot.*, Vol. viii., p. 143.

An Act was passed in 1672* concerning the privileges of royal burghs, granting the right to any of his Majesty's subjects or any person that should buy from them, to export, by sea or land, cattle and a number of commodities, including coal and salt.

In that year idle beggars and vagabonds had the attention of Parliament,† and in an Act for the establishment of correction houses for them, there is a provision which runs as follows :—"It "is always hereby provided that it shall be lawfull to coallmasters, "saltmasters, and others who have manufactories in this kingdom "to seise upon any vagabonds or beggars wherevir they can find "them, and to put them to work in their coal hewghs or other "manufactories, who are to have the same power of correcting "them and the benefite of their worke as the masters of the "correction houses."

By reason of a complaint of inequality of the valuation of lands in different shires, Parliament in 1681 ordered‡ commissioners of supply or excise to revise the valuations where they saw fit; and coal and salt were exempted from bearing any part of the supply.

George, Earl of Winton, in the same year, petitioned Parliament § against his coal rent being valued for public burdens, which had been done during the disturbances in 1649, contrary to custom. The petition was granted, and coal and salt exempted from public burdens.

The Earl of Queensberry got in 1681‖ a ratification of a charter in his favour, of lands in the barony of Drumlanrig, of "not only "ane lead myne already found within the baronie of Sanquhar "pertaining to the said Earle bot likewise all other mynes of "gold silver tinn lead copper and other mineralls and mettalls "whatsoever with the tenth part thereof" on payment of a feu-duty.¶

In 1686, Robert Cunninghame of Auchinharvie was empowered by Act of Parliament** to impose a duty of fourpennies on each

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**Acts Parl. Scot.*, Vol. viii., p. 63.
†*Acts Parl. Scot.*, Vol. viii., p. 91.
‡*Acts Parl. Scot.*, Vol. viii., p. 363.
§ *Acts Parl. Scot.*, Vol. viii., p. 361.
‖ *Acts Parl. Scot.*, Vol. viii., pp. 372-376.
¶ The amount is not stated, but it appears to have been nominal.
***Acts Parl., Scot.*, Vol. viii., p. 609.

pint of ale or brown beer sold in the parishes of Stevenston and Ardrossan during the twenty following years, to enable him to construct a harbour at Saltcoats for exporting the native commodities of that country, and especially coal and salt, wherewith it was said to abound.

In consequence of an embargo having been put on vessels trading with France, a petition* was presented to Parliament by Charles Charters, in 1689, to be allowed to sail to France with a cargo of smithy coal which had been loaded before the embargo was known. He stated, in support of his petition, that the coals were useless for any other port or kingdom. This argument was, of course, irresistible, and the petition was granted.

The natives of royal burghs were in 1690 given the exclusive right† of exporting native commodities, with the exception of corn, cattle, horses, sheep, metals, minerals, coals, salt, lime, and stone.

A patent for 19 years was granted in 1693‡ to Marmaduke Hudson for the sole use of his engine "for draining of coallsinks "limepitts and others of that kind, and freeing them entirely of "water, exceeding by very far all the devices and engines hitherto "made use of for that end in so much that with a little pains and "small expense he is able in ane hours time to free a coalpot of "more water than any other engine hitherto made use of will do "in a week as has been already found by experience amongst the "saltpetter pits in Cornwall."

One-tenth of the ore of Charles Hope's works at Leadhills, or 1000 merks in lieu thereof, was dissolved from the crown in 1695§ and granted to him, he securing a fund of 10,000 merks for the maintenance of a minister for the miners.

A remit was made to the Privy Council in 1696|| to lessen the impost on coal exported in foreign ships to eightpence per ton, as they should find just.

The coal of Cambuskeith was in that year stated to be worth 300 merks a year.¶

Acts Parl. Scot., Vol. ix., App., p. 4.
†*Acts Parl. Scot.*, Vol. ix., p. 152.
‡*Acts Parl. Scot.*, Vol. ix., App., pp. 91-92.
§*Acts Parl. Scot.*, Vol. ix., p. 454.
||*Acts Parl. Scot.*, Vol. x., p. 93.
¶ *Acts Parl. Scot.*, Vol. x., p. 50.

An Act* for the repairing of highways and filling up of coalpits was remitted to a committee of Parliament in 1696, and an overture † for working levels and sinks to mines and coals pits was read in the same year and remitted to the committee for trade, and remitted again to the committee for security in 1698.

In 1698, Lord Elcho presented a petition‡ to Parliament for himself and in name of the other coalmasters of the kingdom, craving that the impost of sixteen shillings per ton might be discharged, at least as to those vessels that came to export coal. The petition was remitted to a committee, and in the same year Parliament reduced the impost § to eight shillings. This was continued for five years.||

The town of Bo'ness made a representation in 1699¶ to the Commissioners for the settling of trade that the coal, which was the only support of the shipping and trade of the town, was nearly worn out, and what remained was so decayed that the proprietors were not able, on account of heavy costs in working and small prices received at home and abroad, to keep their works going; "so that in a short time there will be a total decay "of coal, and the place quite deserted and depopulat, such as "many burghs on both sides of the River of Forth, whose trade "was far more considerable than ours."** The commission, having considered the petition, granted a modification of the quota payable by the town of Bo'ness. This petition refers to export trade with Holland and Norway, timber from the latter country being brought for the use of the coal and salt works. Coal and salt were the chief commodities of Prestonpans and Tranent in 1699.††

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* *Acts Parl. Scot.*, Vol. 10, p. 12.

† *Acts Parl. Scot.*, Vol. x., pp. 18, 133.

‡ *Acts Parl. Scot.*, Vol. x., p. 134.

§ *Acts Parl. Scot.*, Vol. x., p. 175.

|| *Acts Parl. Scot.*, Vol. xi., p. 195.

¶ *Acts. Parl. Scot.*, Vol. x., App., p. 121.

** To a list of salt pans in Scotland in 1686, numbering in all 176, there is attached the following note:—"Ther are severall of the abovenamed panns in decay for want of "incouragement, and effectively ther will be about 160 salt panns now and then going, "but cannot at present make any profit for want of inland consumption."—*Hamilton Papers.*

†† *Acts Parl. Scot.*, Vol. x., App., p. 120.

One of the clauses of an Act passed in 1699,* introducing some much-needed reforms in criminal procedure, illustrates in a marked manner the isolated position of the collier population. The Act prohibited imprisonment without a written warrant duly signed; ordained that all crimes not inferring capital punishment should be bailable, and provided against undue delay in trials: but added:—"And sicklike it is hereby provided and "declared that this present Act is in no wayes to be extended to "coalliers and salters."

Considerable insight is got into the state of the coal works and trade of the country at the beginning of the eighteenth century from an Act which was drafted in 1701, and read in Parliament for the first time in that year.† It narrated‡ that the coal of the kingdom was in many places wholly exhausted, and in every place becoming more expensive to work; that proprietors were scarcely able to keep them going unless measures were taken for their encouragement and preservation; and that advantage might arise by the regulation of the salt manufacture. It then cited and ratified the Acts of 1592, 1606, and 1661, and other Acts relative to the salt manufacture; and, after making certain provisions in favour of salt manufacturers, it declared all iron, timber, and other necessaries imported for the use of coal and salt works, free of duty; and gave additional powers to employers of absconding workmen in the following words:—"And in "respect many of the servants of the coal and salt masters do "withdraw themselves from their service, and are absconded and "concealed by other coal and salt masters, or do retire into "England and there serve until the year and day appointed by "former Acts be elapsed. For remeed whereof, it is statute and "ordained that it shall be lawful to any coal or salt masters by "themselves or others in their name having their warrant to "seize, apprehend, and carry back to their coal and salt works "any collier, salter, or other servant that shall hereafter run "away from their work where and whensoever they shall "discover them, provided the saids masters do previously,

Acts Parl. Scot., Vol. x., p. 274.

†*Acts Parl. Scot.*, Vol. x., p. 293.

‡ It is not printed in the Acts, but the writer has a copy in his possession.

"within year and day after the running away of the said "servants, publickly require them, under form of instrument, at "the mercat place of the head burgh of the jurisdiction where "the runaway lived to return to his said service."

This Act was not passed; and one introduced in 1703* also failed to pass.

A draft Act† was submitted to Parliament and read for the first time in 1701, giving Thomas Rome and partners a monopoly for 21 years of a new art of smelting and refining minerals; and the free use and privilege of any engines for drawing of water out of mines, formerly made use of by them in England.

In 1701 Parliament ratified‡ a charter in favour of the Marquis of Athole and his son dissolving from the crown "all and "sundry the mines of gold silver lead tinn, coper and all other "minerals colours and mettals whatsomever," also the tenth part payable to the crown, within the Earldom of Athole, they paying a nominal feu duty of twenty shillings Scots yearly.

In the same year,§ ratification was made to the same effect in favour of the Earl of March, dissolving from the crown "all "and sundry mines of gold silver lead tin copper and all other "minerals and mettals of whatsomever kind" and the tenth part thereof in the lands of Neidpeth, he paying a feu duty of ten merks Scots a year.

There was also ratified to Sir Hugh Dalrymple in 1701,|| a charter of the lands of Tantallon, with the mines of gold, silver, and other mettals and minerals therein.

The draft of an Act for reviving the Act of 1592 anent mines and minerals was read in 1703¶ and ordered to lie on the table.

David Bruce of Clackmannan had, in 1704, spent considerable sums of money for fitting out and putting in good condition the coals of Clackmannan and Sauchie.**

A draft of an Act dissolving royal mines from the crown was read in 1705†† and ordered to be printed.

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* *Acts Parl. Scot.*, Vol. xi., p. 63.
† *Acts Parl. Scot.*, Vol. x., p. 294; app., p. 101.
‡ *Acts Parl. Scot.*, Vol. x., p. 296.
§ *Acts Parl. Scot.*, Vol. x., p. 300. || *Acts Parl. Scot.*, Vol. x., p. 304.
¶ *Acts Parl. Scot.*, Vol. xi., p. 81. ** *Acts Parl. Scot.* Vol. xi. p. 200.
†† *Acts Parl. Scot.*, Vol. xi., p. 218.

Ratification was made in 1707* of a signature exonerating the Earl of Hopetoun from payment of the tenth part of the ore of the mines of Leadhills, or 1000 merks in lieu thereof, for "three "nineteen years" from Whitsunday 1707.

The Act of 1707† ratifying the Treaty of Union, provided in regard to coal, culm and cinders consumed in Scotland, that, till 30th Sep. 1710, Scotland would be exempted from duty for such.

In an Act, dated 1707,‡ as to customs payable at the bridges of Ramwell Craig and Dunneden, the traffic connected with the mines of the Duke of Queensberry and the Earl of Hopetoun was excepted from pontage for 21 years from 1690.

In confirmation of a letter granted by Queen Anne in 1707, Parliament in that year§ dissolved from the crown in favour of James, Duke of Queensberry the whole "mines of gold silver tinn "lead copper and haill other mettals and minerals whatsomever "of whatever kind nature or quality" in the dukedom of Queensberry, with the tenth part thereof, and all other customs and duties payable to her majesty for the same. The workmen were also granted exemption from "all stent, taxation, imposition, "watch and ward."

The last Act of the Scotch Parliament dealing with coal was passed in 1707,|| and confirmed a grant, made at a former time, to Dame Janet Halket Lady Pitferren, of the full right privilege and liberty to her and her heirs and successors "of transporting "the coals within the bounds of the Estate of Pitferren furthe of "this kingdom free and exempted from all payment of any cus-"tom or bullion or any other duty whatsoever."

Numerous Acts¶ dealing with the coal trade in London and

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* *Acts Parl. Scot.*, Vol. xi., p. 466.

† *Acts Parl. Scot.*, Vol, xi., p. 409.

‡ *Acts Parl. Scot.*, Vol. xi. p. 484.

§ *Acts Parl. Scot.*, Vol. xi., p. 486. || *Acts Parl. Scot.*, Vol. xi., p. 469.

¶ 9 Anne, chap. 30; 3 Geo. II., chap. 26; 4 Geo. II., chap. 30; 17 Geo. II., chap. 35; 21 Geo. III., chap. 34; 28 Geo. III., chap. 53; 45 Geo. III., chap. 128; 46 Geo. III., chap. 71; 46 Geo. III., chap. 104; 47 Geo. III., chap. 34; 47 Geo. III., chap. 45; 48 Geo. III., chap. 95; 49 Geo. III., chap. 72; 50 Geo. III., chap. 110; 51 Geo. III., chap. 11; 51 Geo. III., chap. 29; 51 Geo. III., chap. 83; 52 Geo. III., chap 9; 52 Geo. III., chap. 136; 53 Geo. III., chap. 18; 53 Geo. III., chap. 135; 55 Geo. III., chap 175: 56 Geo. III., chap. 134; 57 Geo. III., chap. 96; 57 Geo. III., chap. 114; 58 Geo. III., chap. 62; 59 Geo. III., chap. 79; 59 Geo. III., chap. 126; 1 Geo. IV., chap. 54; 1 Geo. IV., chap. 67; 1 and 2 Geo. IV., chap. 67; 3 Geo. IV., chap. 59; 5 Geo. IV., chap. 43; 5 Geo. IV., chap. 46; 1 and 2 Will. IV., chap. 16; 2 and 3 Will. IV., chap. 21; 6 and 7 Will. IV., chap. 109.

other parts of the kingdom were passed during the eighteenth and early years of the present century, but as these had only a remote relation to the trade in Scotland no further reference need be made to them.

To protect black lead mines from robbery an Act* was passed in 1751. Offenders were liable to be imprisoned for a year and publicly whipped, or to be transported for a term not exceeding seven years.

By an Act passed in 1768† it was declared to be a felony to wilfully destroy or damage engines for draining or drawing out of coal or other mines; or bridges, waggon ways, and other erections at mines; or fences set up for enclosing lands by virtue of Acts of Parliament; the Court being empowered to transport offenders for seven years, provided the prosecution was commenced within eighteen months after the offence was committed.

The Emancipation Act of 1774‡ was an important measure for the collier population, albeit a tardy acknowledgment of the anomalous state of the law which had suffered a useful section of the community to be kept for more than a century and a half in bondage,§ a condition of things which now we cannot but regard as having been unworthy of the British Constitution. The preamble of the Act set forth that, "Whereas by the Statute "Law of Scotland, as explained by the judges of the Courts of "Law there, many colliers and coal bearers and salters are in a "state of slavery or bondage, bound to the collieries and salt "works where they work for life, transferrable with the collieries "and salt works when their original masters have no further use

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* 25 Geo. II., chap. 10.

† 9 Geo. III, chap. 29.

‡ 15 Geo. III., chap. 28.

§ Attached to a lease of the coal and salt works at Bo'ness in favour of James Cornwall, of Bonhard, in 1681, is a list of colliers and bearers delivered to him conform to the tack of the coall and saltworks:—There are 13 coal hewers; 5 male house bearers, one of whom is reckoned a half; 21 female house bearers, 5 of whom are reckoned a half each; one male *fremd*‖ bearer; and 10 female fremd bearers, 2 of whom are reckoned a half each—in all, 13 coal hewers and 33 bearers. These, with one oncost man, the tenant acknowledges to have received, and undertakes to deliver over at the least a like number at the end of the lease.—*Hamilton Papers.*

‖ See the writer's *Glossary of Scotch Mining Terms.*

"for them; and whereas persons are discouraged and prevented "from learning the art or business of colliers or coal bearers and "salters by their becoming bound to the collieries and salt works "for life where they shall work for the space of one year, by "means whereof there are not a sufficient number of colliers, "coal bearers, and salters in Scotland for working the quantities "of coal and salt necessarily wanted, and many new discovered "coals remain unwrought, and many are not sufficiently wrought, "nor are there a sufficient number of salters for the salt works, "to the great loss of the owners and disadvantage to the publick; "and whereas the emancipating or setting free the colliers coal "bearers, and salters in Scotland, who are now in a state of "servitude, gradually and upon reasonable conditions, and the "preventing others from coming into such a state of servitude, "would be the means of increasing the number of colliers, coal "bearers, and salters, to the great benefit of the publick, without "doing any injury to the present masters, and would remove the "reproach of allowing such a state of servitude to exist in a free "country: May it therefore please your Majesty," &c.

The various heads of the measure were as follows:—After 1st July, 1775, no person beginning to work as a collier, coal-bearer, or salter, was to be bound in any other way than other servants. All persons under 21 years of age at that date, and bound to a work, were to be free after seven years' service. All bound colliers and salters above 21 years of age and under 35, after a service of ten years, and those above 35 and under 45, after a service of seven years, were to be free, provided they had found and sufficiently instructed an apprentice, if required by the master of the work. Those above 45 years of age were to be free after three years' service. If an apprentice were not trained as required, three years' additional service had to be given by those failing to do so. A decree of the sheriff court of the county in which he resided had to be got by each one claiming liberty under the Act, he being obliged to present a petition stating his claim and offering to prove his case. In the event of the sheriff, after notice to the employer and evidence taken, not sustaining his claim, the petitioner could renew it in the same manner at the expiry of a year; and so on, until a decree declaring his freedom was

obtained. Anyone entering into unlawful combinations with others to leave off working, in order to injure his master or to compel him to increase wages or allowances; or who had deserted the work where he was bound, was obliged to work two years additional to those stipulated for before he was entitled to his freedom. Freedom to a collier carried with it freedom to his wife and children and such as were in the family with him as bearers or assistants. Coal-bearers or other labourers not being of the family of the collier were to be free after seven years' service if under 45 years of age, and after three years' service if over that age. Free colliers and salters were to have the benefits of the Act of 1701, already referred to, which had been expressly denied them when that Act was passed.

It may be readily conceived that some of the conditions attached to this emancipation Act were irksome, and that the necessary proceedings entailed, before a decree of freedom could be got, would be too cumbrous and costly for many. At any rate, we find that 25 years later many colliers were still in a state of servitude.

In the coal shipping trade a practice had become very prevalent among shipmasters of entering coastwise shipments that were intended for foreign ports, or of understating the amount of the ship's cargo, in order to evade payment of the export duty. An Act * embracing all the ports of Great Britain was passed in 1785 for the purpose of checking this fraudulent practice.

The exemption from payment of custom or bullion granted to the proprietors of Pitferran by the Act of 1707 was enjoyed till 1788. In 1787† Parliament authorized the Lords Commissioners of the royal treasury to negotiate with the proprietor of Pitferran for a purchase of the right of exemption at "a reasonable and adequate price," the payment of such price to be made out of the revenue of customs in Scotland. The matter was negotiated in the following year, and the sum paid was £40,000.‡

An Act dated 1787 § fixed the duty on coals sent to any port

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* 25 Geo. III., chap. 54.
† 27 Geo. III., chap. 21.
‡ *Treasury Minute Book*, Vol. lx., pp. 38, 71.
§ 27 Geo. III., chap. 13.

in Great Britain at 3s 8d per ton, excepting for coals, culm, and cinders carried coastwise from the bridge of Stirling to the town of Dunbar on the one side, and to Redhead on the other, which were to be free of duty.

In 1793* the duty on coal carried coastwise in Scotland was abolished.

As already indicated, the Act of 1774 to a great extent failed of its purpose, inasmuch as many colliers remained in a state of servitude beyond the time contemplated by that Act. A measure passed in 1799† contained in the preamble the statement that notwithstanding the former Act, "many colliers and coal-bearers "still continue in a state of bondage from not having complied "with the provisions, or from having become subject to the "penalties in the said Act."

It enacted that all colliers who were bound at the passing of the former Act should now be free from their servitude, and in the same situation in every respect as if they had regularly obtained a decree in the manner directed by the said Act. It also declared that the Acts of 1617 and 1661, regulating wages of labourers, extended to colliers and other colliery workers. The Act further narrated that the practice had become general among coalmasters of giving advances to their colliers beyond what they were able to pay, for the purpose of tempting them to enter into or continue their engagements, the sums advanced being kept up as debts against them; and it was enacted that no action for sums lent would be competent, unless for such as were lent for support in case of sickness, the coalmaster being empowered to recover such sums, without interest, at the rate of a twelfth part per week. The seducing of colliers out of Scotland into foreign countries was to be punishable; and the existing laws against combinations of workmen were extended to include colliers and other colliery workers. The impulse given to coal mining by the introduction of Watt's steam engines, and the erection of iron works in various parts of the country towards the end of last century, had caused a demand for colliers probably in excess of the means of supply; and this no doubt

* 33 Geo. III., chap. 69.
† 39 Geo. III., chap. 56.

accounts for the character of this measure and the practices referred to in it. This Act, as first drafted, contained a clause obliging workmen to engage for six months, and to give six weeks' notice to leave, which, with other clauses, was considered by the colliers of Lanarkshire prejudicial to their interests. They organized resistance to the Bill, collected a contribution of two shillings per man from about 600 of their number, sent deputations to collieries in other districts of Scotland for support, and employed a law-agent in Glasgow (Mr Wilson of Cowglen) to conduct the opposition to the Bill in their interests.*

The safety of mines against depredation was provided for by an Act passed in 1800.† It enacted that any person pulling down or filling up any air way, water way, drain, pit, level, or shaft; or damaging any railway, tram road, or other road leading to any coal or other mine work; or, not having a right, should dig mineral from any waste lands, or enter into any level, pit, or shaft with intent to dig or take away mineral, should be guilty of a misdemeanour, and be liable to imprisonment for six months. Any one working coal different from his agreement or contrary to orders, or who refused to fulfil his contract, to be subject to fine or imprisonment. It was the custom to store coal on the hill in separate heaps, money being advanced to each collier on the quantity in his heap. This gave occasion for fraudulent methods of heaping the coal, and stealing from one heap to add to another. These practices were by this Act made punishable by three months' imprisonment; and coal stealing generally and damaging of waggons or tools were made punishable by fine or imprisonment.

Persons selling coals by retail were, by an Act of 1812, excepted from payment of a hawker's licence.‡

An Act of 1816§ declared that any person or persons riotously assembled and with force demolishing any engine or other erections belonging to collieries would be adjudged a felon, without benefit of clergy: that persons whose property was so injured

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* *The Miner*, Jan. 1888.
† 39 and 40 Geo. III., chap. 77.
‡ 52 Geo. III., chap. 108.
§ 56 Geo. III., chap. 125.

would have compensation for the injury sustained, under 1 Geo. I., st. 2, chap. 5, on their giving notice within two days to a magistrate, constable, or inhabitants of the town, village, or hamlet near, and declaring upon oath within four days to a justice of the peace whether they knew any of the persons committing the offence. If they did they were to prosecute, but the action must be commenced within one year after the offence was committed.

By an Act passed in 1817,* two former † acts against Truck in certain trades and manufactures were extended to labouring men working in collieries and other businesses connected with the trade of working and getting coal, in order to secure the payment of every part of their wages in good and lawful money of the kingdom.

The Act of 1816,‡ as to riotous conduct at collieries, was supplemented in 1822 by an Act which directed claims for compensation to be made against the town clerk or clerk of supply and brought before the Justices of the Peace, and made provision for the Commissioners of Supply levying a rate for payment of the sum decreed.

In 1831,§ former Acts relating to payment of wages of workmen in goods or by way of truck were repealed, and a new Act passed,|| embracing, among many others, the persons in or about the working or getting of any mines of coal, ironstone, limestone, &c.

By this Act, contracts for hiring were declared illegal, unless made in the current coin of the realm: and must not contain any stipulations as to the manner in which the wages should be expended. All wages were to be paid in money, and payment by goods was declared to be illegal; but the employer and workman were at liberty to arrange, by an agreement in writing, for the deduction from the wages of the latter of rent, cost of medical attendance, and the true value of fuel materials, tools, and implements supplied to him and employed in his occupation.

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* 57 Geo. III., chap. 122. † 12 Geo. I., chap. 34; and 22 Geo. II., chap. 27.
‡ 3 Geo. IV., chap. 33.
§ 1 and 2 Will. IV., chap. 36.
|| 1 and 2 Will. IV., chap. 37.

Before referring to the next Act, which introduced a new era in Mining Legislation, it may be well to look for a little at some of the more outstanding circumstances out of which it grew. From the beginning of the century, the mining industry quickly rose to a prominent place among the industries of the country. Coal works were being rapidly opened up and extended; and, as outsiders were not readily drawn into that occupation, the colliers enjoyed a good time, wages being high as compared with those of other labouring occupations. As soon as the country got into a settled condition after the war culminating in the battle of Waterloo, the demand for coal quickly exceeded the supply, and colliers became scarce. The abolition of the Combination Laws, in 1824, enabled workmen to meet together and form themselves into Associations. Taking advantage of their newly-found liberty, the miners of the West of Scotland formed themselves into a Union, for the purpose of regulating the rate of wages, and other matters connected with the coal trade. Favoured by the pressure of trade and the demand for coal, they proceeded to restrict their output, so much so, that in 1825, in the West of Scotland, wages had risen, in some cases, to ten shillings a day of eight hours, and the week's work had been reduced to three or four days. To discourage the introduction of strangers who were attracted by the high wages, the Union imposed a sum of five pounds of entry-money on each new comer, and other equally vexatious restrictions were sought to be imposed on the mining industry. This state of things was carried to an intolerable extent, and led to the introduction, on a large scale, of strangers, particularly Irish labourers, into the pits in Scotland; and eventually brought about a collapse of the Miners' Union. With the rapid increase of workers and influx of strangers brought from all parts, and often located at places remote from towns and sanitary supervision, existing evils were intensified, and attention was thereby more generally drawn to the very unsatisfactory conditions of living and labouring of many of the collier population. Moreover, the opening out of deeper workings brought more prominently into view the dangers amid which the miner laboured; and the desirability of supervision of mines by the State was forced on men's minds by the frequent occurrence of serious min-

ing disasters. The deeper and more fiery mines of the North of England, where serious explosions were frequent, naturally attracted more attention than the Scotch mines, and it is there we find the first movements made towards the recognition of the need of Government regulation of mines. So far back as 1797* proposals had been made for the establishment of an office for colliery plans and records; and in 1813† a society was formed in Sunderland for the prevention of accidents in mines. It was not, however, till 1831 that Government took any active interest in the matter. In that year a Select Committee was appointed "to "inquire into the nature, cause, and extent of those lamentable "catastrophes which have occurred in the mines of Great Britain, "with the view of ascertaining and suggesting the means for pre-"venting the recurrence of similar fatal accidents." The subjects which the Committee set themselves more particularly to inquire into were included under these three heads :—Ventilation, Safety Lamps, and Maps or Plans. They also put to themselves the question "how far legislative enactments might come fairly in aid "of the miner." In their report issued in 1835, they did not make any distinct proposals, and no definite reply was given to their own question. At the same time, prominence was given to the following points :—The want of accurate information as to loss of life by accidents was felt, and the desirability indicated of returns being sent to the Secretary of State. The importance of ventilation was recognised; the need of more shafts emphasized, and wooden bratticing in ventilating shafts condemned; while it was admitted that generally aircourses were not kept sufficiently distinct. The great value of the Davy lamp was acknowledged; but attention was drawn to its unsafety in certain circumstances which had been known to Sir Humphry Davy, but not made sufficiently public. A committee was formed in South Shields in 1839, for the purpose of inquiring into the causes of accidents in mines, and valuable evidence was collected and opinions advanced in a report published in 1843, quite confirming these indicated by the Select Committee of 1835. The Davy lamp without a shield was declared unsafe; air-currents were held to be as a rule too

*Galloway's *History of Coal Mining*, p. 221.
† Ibid, p. 159.

slow on account of shaft area being too small. Forewinning of new seams by advance mines so as to draw off gas was recommended; and the use of the barometer, thermometer, and anemometer advised. The opinion was stated that 12 years of age should be the lowest limit for those commencing work in the mines; and the committee was convinced of the utility of having plans and sections registered. They advised the scientific education of mining engineers and mining officials, and declared that "the advantages derivable from an enlightened public jurisdiction "in a well-organised system of government inspection are clear and "indubitable." Before this committee's report was published, the Report of the "Children's Employment Commission" of 1842 was issued, and immediately secured wide attention. The facts brought to light by that Commission as to the wretched state of some of the females engaged in mines in England and Scotland, and the utterly unsuitable nature of the labour for women, girls, and young boys, led to the passing of an Act* in that year prohibiting the employment of females, and boys under 10 years of age, in any mine or colliery. Government inspection was also provided for, to the extent that the Secretary of State was empowered to appoint any proper person or persons to inspect any mine or colliery and works belonging thereto about any matter within the provisions of the Act, the owners or agents being required to give the necessary facilities, and the Inspector to report to the Secretary of State as directed. The other points in the measure were as follows:—No person regularly employed underground was to be indentured for a longer period than 8 years. The engine connected with any shaft or inclined plane on which men were raised was to be under the charge of a person over 15 years of age. Payment of wages at a public-house was prohibited. Agents acting contrary to the Act without the knowledge of the owner might be summoned and convicted in place of the owner. The other clauses related to penalties and legal procedure.

Had the report of the South Shields Committee preceded that of the Children's Employment Commission, very probably the Act of 1842 would have contained a more comprehensive scheme

* 5 and 6 Vict., chap. 99.

of inspection. The duty of the inspector who was appointed under that Act in 1843, and held office till 1859, did not include underground examination, but he did good work in bringing prominently into notice, in his annual reports, the social and sanitary condition of the mining population.

Numerous and notable as are the additional provisions made in each succeeding Act since 1842, it will be found that the necessity of them was recognised and insisted on years before they had a place in the statute book. This is most noteworthy in regard to inspection. Matthias Dunn* and others in 1844 advocated Government interference, and during the eight years from 1842 to 1850 numerous reports from select committees and special commissioners were submitted to Parliament, in all of which the desirability of a system of Government inspection of mines underground was advocated.† Moreover, a special commissioner had been sent to Belgium, France, and Germany, to examine the system of inspection in these countries, and had reported favourably in 1847; but it was not till 1850 that an Act carrying out to some extent these many recommendations was passed. It was stated in the Report of the Select Committee of 1849 that the mines of Scotland were comparatively free from danger from explosions: on the other hand, Mr Matthias Dunn‡ had affirmed that the proportion of deaths from other causes was comparatively more numerous in Scotland than in England, from which it may fairly be inferred that, if the mines of England were to be the better of Government inspection, Scotch mines required it too.

The Act of 1850§ dealt entirely with the subject of inspection. The Secretary of State could appoint fit persons to be Inspectors of Coal Mines, who should have power to enter and inspect any coal mine or colliery at all times, and to make inquiry into the condition of such, and, generally, into all matters relating to the safety of the persons employed, the owner or agent being required to give the necessary facilities. The inspector, on finding any-

* Dunn's *View of the Coal Trade*, p. 102.

† An interesting chapter on this subject will be found in Galloway's *History of Coal Mining*, pp. 220-246.

‡ Dickinson—*Trans. Manch. Geol. Soc.*, Vol, xix., p. 28.

§ 13 and 14 Vict., chap. 100.

thing dangerous or defective, could summon the manager before him, and, failing satisfaction, was to serve written notice on the owner or agent, and also report the same to the Secretary of State. The owner had to produce a plan of the workings to the inspector when desired, who, if satisfied of its incorrectness, had power to require an accurate plan to be made, but was not permitted to copy the plan. No person acting as a land agent, or as a manager or agent of a mine, could act as an inspector. Notice of accidents in mines was to be given to the Secretary of State.

This Act was to continue for five years.

The reports of the select committees of 1852, 1853, and 1854, and a visit of inquiry to the continent in 1853, prepared the way for the very considerable advance which is to be observed in the Act of 1855.*

It repealed the former Act, but retained the inspectors appointed under it, and enacted as follows :—

Inspectors might be appointed by the Secretary of State.

No one employed in any way about mines to act as an inspector.

The following general rules to be observed :—

1. Adequate ventilation to be constantly produced, to render harmless noxious gases, so that working places and levels should be in a fit state for working.
2. Disused or air shafts to be fenced.
3. Working shafts to be fenced when not at work.
4. Working shafts to be lined where the strata were unsafe.
5. Working shafts to be provided with means of signalling between surface and bottom.
6. Machines raising and lowering persons to be provided with indicator and adequate brake.
7. Every steam boiler to have a steam gauge, water gauge, and safety valve.

Special Rules were to be made for each colliery, with the approval of the Secretary of State, "for the conduct and guidance of the "persons acting in the management of every coal mine or colliery, "and of all persons in or about the same as under the particular

* 18 and 19 Vict., chap. 108.

"state and circumstances of such coal mine or colliery, may appear "best calculated to prevent dangerous accidents." General and Special Rules to be printed and exhibited at the colliery office, and a copy given to each person employed. Powers and duties of inspectors were defined, and were fuller than under the former Act. Owners of mines were obliged to produce plans of the workings, extended to within six months previously, when required by the inspector, failing which, or the plans being incorrect, the inspector would require plans to be made. Notice of accidents to be given to the Secretary of State. Each inspector to make a yearly report to the Secretary of State, to be laid before Parliament. Other clauses referred to penalties and procedure.

This Act, which was for Great Britain, was to continue in force for five years.

After the lapse of five years, the Act of 1860* was passed. It was divided into two parts, the first part being applicable to all mines in Great Britain, and the second to coal and ironstone mines only. In the first part it was provided that no boy under twelve years of age was to be employed in any mine, unless he could read or write, or was at school for three hours two days a-week; and that no one under eighteen years of age was to have charge of an engine raising persons.

In the second part the Act of 1855 was repealed, and mines of ironstone of the coal measures included with coal mines.

The appointment of inspectors was provided for in the same terms as in the former Act.

Experience had justified the utility of the General Rules established under the former Act, and their number was in this Act increased to fifteen. Their substance was as follows :—

1. Adequate ventilation to be constantly produced, so that the working places and travelling roads should be in a fit state for working and passing therein.
2. Places not in course of working, and suspected to contain dangerous gases, to be fenced off to prevent access.

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* 23 and 24 Vict., chap. 151.

3. Safety lamps, when required to be used, to be examined and securely locked by an authorized person.
4. Disused shafts to be securely fenced.
5. Working shafts to be securely fenced during suspension of operations.
6. Working or pumping shafts to be lined where strata were unsafe.
7. Working shafts to be provided with means of signalling between surface and bottom.
8. Underground self-acting or engine planes to have means of signalling, and refuge holes not more than twenty yards apart.
9. Persons raised or lowered in working shafts to have a sufficient cover overhead.
10. Single-linked chains, for raising or lowering persons, prohibited.
11. The driver of every machine, used for raising or lowering persons, to have flanges or horns.
12. Every machine used for raising or lowering persons to have an indicator and adequate brake.
13. Every steam boiler to be provided with a proper steam gauge, a water gauge, and a safety valve.
14. The fly-wheel of every engine to be securely fenced.
15. Sufficient bore-holes to be kept in advance, and, if necessary, on both sides of a working approaching a place likely to contain a dangerous accumulation of water.

The Special Rules established under the former Act were to continue in force, and provision was made for establishing new special rules, and amending existing ones from time to time. The powers and duties of the inspectors were defined in substantially the same terms as in the former Act, with the addition that the inspector was empowered to give notice to the mine-owner and to the Secretary of State of causes of danger not provided for in the Act or in the Special Rules. Notice of accidents, causing loss of life or personal injury, to be given to the Secretary of State. Notice of abandonment, or recommencement, or new opening, of a mine, to be sent to the inspector.

Reports of Inspectors to be sent to the Secretary of State each year and laid before Parliament.

Wages to be paid in money in a place to be appointed in the Special Rules, and not contiguous to any house where spirituous liquors were sold. Where the persons employed were paid by the weight, measure, or gauge, the mineral was to be truly weighed, measured, or gauged; and the persons employed were empowered to station at their own cost one of their number at the weighing place to take account on their behalf. Other clauses dealt with penalties and legal procedure. This Act was to commence on 31st December, 1860.

The accident at Hartley Colliery, whereby the only shaft was blocked up, causing the death of 204 miners by suffocation, was the immediate occasion of the passing of the Act of 1862.* This Act was to be held as one with that of 1860, and prohibited single shafts in new collieries after the passing of the Act, and in existing collieries after 1st January, 1865. Each coal and ironstone mine was to have two outlets divided by at least ten feet of strata, and available for ingress and egress to persons in the mine. The Act was not to apply to a new mine proving minerals, or any working making communication between two shafts, so long as not more than twenty persons were employed therein. Provision was made for those who objected to the Act on the ground of their mineral being nearly exhausted, or the time being too short to provide a second outlet, or other cause, to submit their case to arbitration.

Mining matters were frequently before Parliament during the next ten years. A commission of inquiry to collieries on the Continent reported in 1863. Several great explosions occurred in 1866, notably that of the Oaks, which is the largest in the annals of mining, and a Select Committee on Accidents in Mines reported in 1867. Opinion generally was tending towards the desirability of a higher standard of education for those engaged in superintending mining operations; further restrictions in the use of explosives; safer laying out of ventilation districts; and a more

* 25 and 26 Vict., chap. 79.

general adoption of safety lamps. Reference may here be made to the Coal Commission which was appointed in 1866 and reported in 1871 on the probable duration of the coalfields in Great Britain; the probable limit of depth; the condition and prospects of home consumption and export; and waste in working and consumption. The report showed that fears which had been entertained of the early exhaustion of our coal were not well grounded, but it brought prominently into view the very wasteful methods of working that were still so common. Although no legislation on the subject followed on this report, yet there is no doubt the facts there brought out served to put a check on old systems of working involving unnecessary and unjustifiable loss of coal.

The Coal Mines Regulation Act of 1872* took effect on 1st January, 1873. It applied to mines of coal, stratified ironstone, shale and fire-clay, and the following is an epitome of its provisions :—

No boy under ten years of age, or any female, to be employed underground. Boys between ten and twelve years might be employed, with the consent of the Secretary of State, in thin seams, under certain restrictions as to working hours and school attendance. Boys between twelve and sixteen were not to be employed underground for more than 54 hours in one week, or more than 10 hours in one day.

No person under ten years of age to be employed above ground. Women, and boys under sixteen, were not to be employed above ground more than 54 hours in a week, or more than 10 hours in one day, or between nine at night and five on the following morning, or after two o'clock on Saturday afternoon; meal times to be provided for such of not less than half-an-hour for each period of work exceeding five hours, and an hour and a half for each period exceeding eight hours.

The engine or machine of any shaft or inclined plane on which persons were raised and lowered to be under the charge of a male person not under 18 years of age.

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* 35 and 36 Vict., chap. 76.

A novel feature in this Act was the putting the onus of proof of innocence in case of contravention by any one upon the owner, agent, or manager. Throughout the Act the owner, agent, and manager were each held guilty, in the case of contravention or non-compliance by any person, unless he proved that he had taken all reasonable means, by publishing, and to the best of his power enforcing the provisions of the Act, to prevent contravention or non-compliance. No wages to be paid in or near a public-house, or other house of entertainment.

Where wages depended on weight of mineral gotten, the mineral to be truly weighed, subject to arrangement for deduction of stones or mineral other than that contracted to be gotten. The Secretary of State to have power to exempt mines from payment of wages according to weight. Workmen paid according to weight might employ a check-weigher, being one of the persons employed at the mine, or in a mine belonging to the same owner, to take account of the weight of mineral gotten by those by whom he was employed, he receiving facilities for so doing, but not being authorized to interfere with the weighing. A check-weigher impeding the working, or interfering with the weighing, or misconducting himself, might be removed by the Court. The Weights and Measures Act, 5 and 6 William IV. c. 13 was to apply to the weights and measures in use in terms of this Act.

Each mine to have two outlets separated by not less than ten feet of strata, and having a communication between them of not less than four feet wide and three feet high, and apparatus for raising and lowering persons at each shaft, or available in a reasonable time. The double outlet was not compulsory in the case of a mine proving minerals, or of a communication between shafts when not more than 20 men were employed, or of a mine exempted by the Secretary of State because of insufficient mineral to repay the cost of a second outlet, or of one of the outlets being cut off by working back of pillars, or of not more than 20 men being employed underground, or in case of accident to one of the outlets. A claim for exemption or extension of time to make the second outlet might be submitted to arbitration.

Parts of a mine worked separately, and after intimation to the Inspector, might be deemed separate mines, unless the Secretary

of State objected, in which case the matter could be decided by arbitration.

Each mine to be under the daily supervision of a manager, holding a certificate under the Act. Mines employing less than 30 persons underground, or putting out not more than 25 tons daily, to be exempt from this provision, unless the Inspector required the same to be under a manager. For the purpose of granting certificates of competency to managers, examiners were to be appointed by a Board, consisting of three owners of mines, three persons employed in the mines not being owners, agents, or managers, three persons practising as mining engineers, and one Inspector under the Act. Applicants, on payment of a fee of two pounds, and after examination and satisfying the examiners of their sobriety, experience, ability, and general good conduct, on being reported to the Secretary of State, were to receive a certificate. Certificates of service, having the same effect as those of competency under the Act, could be had by such as, within five years previous to the passing of the Act, had acted for twelve months as a manager of a mine. The certificate of a manager might be cancelled by the Secretary of State if, after public inquiry, he were found incompetent, grossly negligent, or convicted of an offence against the Act. Cancelled certificates might be restored, and lost ones renewed, by the Secretary of State.

Expenses incurred by the Secretary of State in carrying into effect the provisions of the Act were to be paid out of moneys provided by Parliament, and fees paid by applicants for examination carried into the Consolidated Fund.

Returns to be made on 1st February in each year to the inspector, of the quantity of mineral worked, and the number of persons ordinarily employed in each mine, during the year to the preceding 31st December.

Notice to be given to the inspector of all accidents involving loss of life or personal injury.

Notice to be given to the inspector of the commencement of a new mine; abandonment or discontinuance of the working of a shaft; recommencement after abandonment of two months or more; or change in name of a mine or management thereof.

Abandoned mines to be fenced.

Plans of abandoned mines to be sent to the Secretary of State, and no one without the mine owner's consent to see such plans for ten years.

Inspectors might be appointed by the Secretary of State. Any one employed about a mine not to act as inspector. The inspectors' duties and powers were as follows:—An inspector to have power to make examination and inquiry to ascertain whether the provisions of the Act were being complied with; to enter and examine any mine by day or night, but so as not to impede the working; to examine and make inquiry as to the condition of the mine, ventilation, sufficiency of special rules, and all matters relating to safety; to exercise such other powers as might be necessary for carrying the Act into effect; and to take notice of anything tending to the bodily injury of any person, although not provided for in the Act or in the special rules, and give notice of the same to the owner, agent, or manager, and report to the Secretary of State, who, if the matter complained of were not remedied, would cause it to be settled by arbitration.

Plans of the mines, shewing the workings up to at least six months previously, to be kept at the office at the mine, and shewn to the inspector when required, who, if material information which the plans should contain were withheld, could, by written notice, require the owner to cause accurate plans to be made.

Every inspector to make an annual report to the Secretary of State, to be laid before both houses of Parliament.

Provisions were made for guidance in cases of arbitration.

The General Rules, which were much more numerous than in the Act of 1860, and were to be observed so far as reasonably practicable, were in substance these:—

1. An adequate amount of ventilation to be constantly produced in every mine to render harmless noxious gases, so that the working places, levels, stables, and travelling roads should be in a fit state for working and passing therein.
2. In every mine where inflammable gas was found within the preceding twelve months, an examination once in twenty-four hours where a single shift was employed, and once in

twelve hours where a double shift was employed, to be made before the time of commencing work in any part of the mine of that part and the roadways leading thereto by a competent person with a safety lamp, the state of the workings so examined to be recorded in a book to be kept for the purpose.

3. A mine in which inflammable gas had not been seen for twelve months to be examined once in twenty-four hours, and its true condition as far as ventilation was concerned to be recorded in the report book.
4. Places not in actual course of working to be fenced off, to prevent persons entering the same.
5. Stations to be appointed at the entrance or in different parts of the mine, beyond which workmen were not at liberty to pass, until the part of the mine beyond had been inspected and stated to be safe.
6. Workmen to be withdrawn if at any time the mine or part thereof was found by the person in charge to be dangerous on account of noxious gases or otherwise; and not to be re-admitted until a competent person appointed for the purpose reported it not to be dangerous.
7. Only a locked safety lamp to be used in every place approaching a suspected accumulation of explosive gas. Whenever safety lamps were required to be used, the same to be examined and securely locked by a competent person appointed for the purpose, before being taken into the workings for use, and not to be unlocked without due authority; and no one but the competent person to have in that part of the mine any key or contrivance for opening the lamp lock, or match or apparatus for striking a light.
8. Gunpowder or other explosive or inflammable substance not to be stored in the mine, nor taken there except in a canister containing not more than four pounds. Only one such canister to be in use at any one place at one time. Iron or steel prickers and stemmers not to be used in charging holes for blasting. A charge of powder that had missed fire not be unrammed. The explosive to be taken

into the mine and used only in cartridges, and under the following restrictions, during three months after any inflammable gas had been found in such mine:—A competent person to examine the place where the shot was to be fired, and the places contiguous thereto, and a shot not to be fired unless by or under the direction of a competent person. If gas shewed a blue cap on the safety lamp the explosive should only be used either in stone work where the return air passed into the return air course without passing into any place in course of working; or when the workmen were out of the part of the mine where it was used. The provisions of this rule as to explosives to apply to each panel having an independent intake and return airway from the main air course, as if each such panel were a separate mine.

9. Places likely to contain a dangerous accumulation of water to be approached by a working not exceeding eight feet wide and having a bore hole not less than five yards in advance, and sufficient flank bores on each side.
10. Self-acting or engine planes exceeding thirty yards in length, on which persons travelled, to be provided with means of signalling, and have manholes at intervals of not more than twenty yards.
11. Man holes to be provided every fifty yards, or a space three feet wide between the waggons and the side of the road, on roads underground on which persons travelled where the load was drawn by a horse.
12. Every manhole to be kept clear.
13. The top of every shaft out of use, or an air shaft, to be securely fenced.
14. All entrances to working and pumping shafts to be fenced, subject to removal under proper precautions.
15. Working and pumping shafts to be lined where the strata were unsafe.
16. The roof and sides of every travelling road and working place to be made secure.
17. Every person employed to have the option of using the downcast shaft where the upcast was a furnace shaft.

18. The person who worked the machinery for raising or lowering persons to attend for that purpose during the whole time that any person was below ground in the mine.
19. Every working shaft more than fifty yards deep to have guides and means of signalling to and from the surface and bottom and intervening entrances.
20. A sufficient cover overhead to be used when raising or lowering persons in every working shaft.
21. A single linked chain not be used for raising and lowering persons.
22. Appliances to prevent slipping of the rope to be on the drum of every machine used for lowering and raising persons.
23. Every machine worked by mechanical power used for raising or lowering persons to have an adequate brake, and a proper indicator to mark the position of the load or cage in the shaft.
24. Exposed and dangerous parts of machinery used in or about a mine to be securely fenced.
25. Every steam boiler to have a steam gauge, water gauge and safety valve.
26. A barometer and thermometer to be placed near the entrance of each mine after dangerous gas had been found in it.
27. Wilful damage or removal of fencing, lining, guides, signalling, &c., above provided for, prohibited.
28. Every person to observe the directions given him with a view to comply with the Act or the special rules.
29. A competent person to examine once in twenty-four hours the machinery, head gear, working places, levels, planes, ropes, chains, and other works of the mine in actual use, and the state of the shafts by which persons ascended and descended, at least once a week, and make a true report of the same in a book to be kept for the purpose.
30. The workmen were empowered to appoint two of their number, at their own cost, to go once a month to every part of a mine, and inspect the shafts, levels, planes, working places, return airways, ventilating apparatus, old

workings and machinery—the owner, agent, and manager, and all persons in the mine, being obliged to afford them every facility for the purpose; and a true report of the result to be entered in a book to be kept for the purpose.

31. The books mentioned in this section to be kept at the office at the mine, and to be open to the inspection at all reasonable times of the Inspector or any one employed in the mine.

Special rules to be established at every mine for the guidance of those engaged about the same to prevent accidents and provide for safety and discipline; the rules and amendments thereof on being approved by the Secretary of State, or, in the event of difference of opinion, settled by arbitration, to be signed by the Inspector of the district, and to have the strength of the Act. These rules and an abstract of the Act to be posted up at the mine, and a copy thereof to be given to each workman on application.

Provision was also made for penalties for offences against the Act and legal procedure. The penalty for an offence by an owner, agent, or manager was not exceeding £20; any other person, £2. An offence calculated to endanger the safety of the persons in or about a mine, or to cause a dangerous accident, could be punished by imprisonment for not more than three months.

The Acts of 1842 and 1860, so far as relating to mines to which this Act applied, and the Act of 1862, were repealed.

The Metalliferous Mines Regulation Act of 1872* applied to every mine of whatever description, other than a mine to which the Coal Mines Regulation Act, 1872, applied. It was framed on similar lines to that Act, many of the clauses being identical, and others made to suit the special circumstances of metalliferous mining. It came into force on 1st January, 1873.

The Explosives Act of 1875† regulates the storage of gunpowder and other explosives.

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* 35 and 36 Vict., chap. 77.
† 38 Vict., chap. 17.

An Act* to amend the provisions of the Metalliferous Mines Regulation Act of 1872 with respect to the Annual Returns from Mines was passed in 1875.

The Employers' Liability Act, 1880,† may be referred to as affecting the mining industry. Personal injury sustained by a workman on account of defective ways, works, machinery, or plant used in the business of his employer; or on account of negligence in those to whom the workman was obliged to conform, entitled him, or, in case of death, his representatives, to the same right of compensation against his employer, as if the workman had not been in the service of his employer; the amount of compensation recoverable being limited to not more than three years' wages.

The Stratified Mines (Gunpowder) Act, 1881‡ empowered the Secretary of State to exempt mines of stratified ironstone in the lias formation from so much of general rule eight in the Coal Mines Act of 1872, as forbade gunpowder or other explosives being taken into a mine except in cartridges.

A short Act was passed in 1886§, repealing so much of the Act of 1872 as required that a checkweigher should be one of the workmen, and enacting as follows :—"In all cases where a check-"weigher has been appointed by the majority of the colliers "working in any mine, and has acted as such, he may recover "from any collier working in such mine his proportion of the check-"weigher's wages or recompense, notwithstanding that any "colliers or collier may have left the colliery, or others have "entered the same, since the checkweigher's appointment." The owner or manager was empowered to retain the checkweigher's wages from the workmen and pay the same to the checkweigher.

This Act also provided for holding public investigations in the case of accidents, if thought expedient by the Secretary of State.

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* 38 and 39 Vict., chap. 39.
† 43 and 44 Vict., chap. 42.
‡ 44 and 45 Vict., chap. 26.
§ 49 and 50 Vict., chap. 40.

The Truck Amendment Act of 1887,* which is supplemental to the Act of 1831, prohibits any deduction on account of poundage, discount, or interest being made from wages for cash advances. It also prohibits deductions for repairing or sharpening tools except by agreement not forming part of the condition of hiring. When deductions are made from workmen's wages for education of children, or in respect of medicine, medical attendance, or tools, the employer is to submit the accounts of the same yearly to two auditors appointed by the workmen.

The Coal Mines Regulation Act of 1887,† which came into force on 1st January, 1888, is the last and longest of the series under review. There is no doubt that the Royal Commission on Accidents in Mines, which was appointed in 1879, and laboured without intermission for seven years, issuing a preliminary report in 1881, and a final report in 1886, influenced in no small degree the minds of the framers of this Act; and some of the recommendations contained in that report have been carried into effect in it. Of late years, too, the subject of the influence of coal dust in colliery explosions has been forced prominently into notice by the occurrence of great explosions, the cause of which could be accounted for in no other way, and this now fully recognised, although long suspected danger, is provided for in the Act. The Royal Commission referred to, also, after elaborate trials, emphasized the conclusions which had been arrived at by individual experimenters, as to the unsafety in many conditions met with in mines of so-called safety lamps. Moreover, blasting in fiery mines had been proved to be a fruitful source of danger. Prominent, therefore, among the regulations in this Act are those in respect of blasting and the use of safety lamps in fiery and dusty mines.

Carrying out the method adopted in referring to the former Acts, there now follows, in terms as brief as is consistent with clearness, a description of the various clauses of this Act.

It applies to mines of coal, stratified ironstone, shale and fire-clay, and is divided into three parts. Part I. relates to employ-

* 50 and 51 Vict., chap. 46.
† 50 and 51 Vict., chap. 58.

ment of boys, girls, and women; wages; single shafts; division of mine into parts; certificated managers; returns, plans, notices, and abandonment; inspection; arbitration and inquests; part II., to general and special rules; and part III., to legal proceedings; miscellaneous and transitory provisions; and repeal of former Acts.

PART I.

Employment of Boys, Girls, and Women.—No boy under 12 years of age, and no girl or woman, to be employed underground. No boy above 12 to be employed underground for more than 54 hours a week, or 10 hours a day.

Aboveground, no girl or boy under 12 to be employed. A girl or boy under 13 may be employed under restrictions as to working hours. Boys and girls above 13 and women not to be employed more than 54 hours a week or 10 hours a day, nor between 9 at night and 5 in the morning, nor after 2 o'clock on Saturdays. A meal time of half an hour to be given for 5 hours' work, and an hour and a half for 8 hours' work. No boy, girl, or woman to be employed moving railway waggons. A register to be kept of all boys, girls, and women employed at the mine.

As in the former Act, the owner, agent, and manager are each held guilty of a contravention or non-compliance of this and the other provisions of the Act, by any person, unless he proves that he has taken all reasonable means by publishing, and to the best of his power enforcing, the provisions of the Act, to prevent contravention or non-compliance.

School fees of any boy or girl attending school and employed at a mine may be deducted from wages earned.

Wages.—No wages to be paid in or near any public-house, or other house of entertainment.

When wages paid depend on the weight of mineral gotten, the mineral contracted to be gotten to be truly weighed at the pit-mouth, subject to such an arrangement for deductions in respect of stones as may be agreed on. In mines employing not more than 30 persons, the workmen and owners may, with the consent of the Secretary of State, arrange for wages being paid according to other methods than that provided for in the Act.

The persons employed in a mine who are paid according to the weight of mineral gotten, may at their own cost station a check-weigher at the weighing place, to take account of the weight of mineral and deductions, he to have every facility afforded him for the fulfilling of his duties, including testing of the weighing machine and tareing of tubs, but not to impede the working, or interfere with the weighing, or with the workmen, or management of the mine. A check-weigher infringing these conditions may, on the application of the owner, agent, or manager, be removed by the Court. A check-weigher appointed by ballot by the majority of those paid according to the weight of mineral gotten, can recover from any one employed and so paid his proportion of check-weigher's wages, whether or not he was a party to the employing of the check-weigher. The owner or manager may retain the check-weigher's wages from the workmen, and pay them over to him.

The Weights and Measures Act of 1878 to apply to the weights used under this Act. Weights to be examined by the Inspector of Weights and Measures at least once in six months.

Single Shafts.—Every seam in a mine to have two outlets, not nearer one another—in the case of shafts sunk after 1st January, 1888—than 15 yards, with a communication between them not less than 4 feet wide and 4 feet high; and proper apparatus for raising and lowering persons in each shaft to be constantly available for use. Exceptions are allowed from this provision (1) in the case of a new mine being opened to make a communication between shafts, or to search for minerals so long as not more than 20 persons are employed; (2) if the Secretary of State exempts on the ground of there being insufficient mineral to work to justify the expense of a second outlet, or that the second outlet may be cut off by working back of pillars, and so long as not more than 20 persons are employed; (3) if the Secretary of State exempts while a shaft is being sunk, or while one of the outlets has by accident become unavailable.

Division of Mine into Parts.—Two or more parts of a mine worked separately may, on notice being given and consent of Secretary of State got, or failing which, on settlement by arbitration, be deemed separate mines.

Certificated Managers.—Every mine to be under the control of a manager holding a first-class certificate under this Act. A mine employing not more that 30 persons to be exempt, unless the Inspector requires that it be under the control of a manager. Daily personal supervision in every mine to be exercised by the manager, or an under-manager, nominated by the owner or agent, and who shall have a first or second-class certificate under this Act, and in the absence of the manager have the same responsibility as he and jointly with him. A contractor for mineral, or one employed by him, not to be eligible as manager or under-manager. No one to be entitled to a first-class certificate of fitness to be manager, or second-class certificate of fitness to be under-manager, unless he has had practical experience in a mine for at least five years. For granting certificates, examiners to be appointed by a Board holding office during the pleasure of the Secretary of State, and consisting of three owners of mines, three persons employed in or about mines (not being owners, agents, or managers), three mining engineers, agents, managers, or coal viewers, and one inspector. Applicants, after payment of £2 in the case of first class certificates and £1 in the case of second-class certificates, having satisfied the examiners of their sobriety, experience, ability, and general good conduct, and been reported to the Secretary of State, have delivered to them a certificate of competency. The certificate may be cancelled by the Secretary of State, in the case, proved in Court, of incompetency, negligence, or unfitness ; or of a conviction for an offence against the Act. Cancelled certificates may be restored and lost ones renewed.

All expenses incurred by the Secretary of State in carrying out the Act to be defrayed out of moneys provided by Parliament; and all fees payable by applicants to be carried to the Consolidated Fund. Any one forging a certificate or making a false declaration in connection therewith to be liable to imprisonment.

Returns, Plans, Notices, and Abandonment.—Returns to be sent to the Inspector on 21st January in every year, of the number of persons employed, quantity of mineral worked, number of days in which mineral has been drawn, and particulars as to ventilation for the year ending the preceding 31st December, which the

Secretary of State may publish; but the particulars as to mineral gotten at any particular mine not to be published separately without the consent of the mine owner.

An accurate plan of the mine shewing the state of the workings up to a date not more than three months previously, and showing direction and rate of dip and a section of the strata sunk through, or, if that be not reasonably practicable, a statement of the depth of the shaft with a section of the seam, to be kept at the mine and exhibited to the inspector when required, who shall be entitled to copy any part of the same for official purposes. If the plan be not shown, or if material information be withheld, the inspector may require the owner, agent, or manager to cause an accurate plan and section to be made, within a reasonable time, at the expense of the owner.

Notice to be given to the inspector of accidents above and below ground resulting in loss of life or personal injury; the place where the accident occurred to be left as it was for three days, or until visited by the inspector, unless the so doing would impede the working of the mine.

Notice to be given to the inspector of the opening of a new shaft; of the abandonment or discontinuance of a shaft or seam of any mine; of the recommencement after two months' discontinuance; and of any change in the name of the mine, or in the name of the owner, agent, or manager.

The top of every shaft and side entrance to an abandoned or discontinued mine to be fenced.

An accurate plan of each mine when abandoned to be sent to the Secretary of State; but no one except an inspector under this Act to be at liberty, without the consent of the owner of the mine, to see the plan until after the expiry of ten years.

Inspection.—Inspectors may be appointed by the Secretary of State and paid out of moneys provided by Parliament. Any person employed in or about a mine, or a miners' agent, or mine owner, shall not act as inspector; and no inspector shall be a partner, or have any interest in any mine in the district under his charge. An inspector to have power to make examination and inquiry as to whether the Act is complied with at any mine; to enter and inspect any mine by night or day, but so as not to

impede the working; to examine into and make inquiry as to the condition of the mine, the ventilation, sufficiency of special rules, and all matters relating to the safety of the persons employed, or the care and treatment of the horses; and to exercise any other powers necessary for carrying the Act into effect. The inspector may also take cognizance of any matter not provided for in this Act or in the special rules, which is dangerous or tends to the bodily injury of any person, and give notice of the same to the owner, agent, or manager, and report to the Secretary of State. The matter complained of, if not remedied, may be submitted to arbitration.

Every inspector to make an annual report to the Secretary of State, which shall be laid before both Houses of Parliament.

The Secretary of State may direct a special report to be made in the case of an explosion or accident causing loss of life or personal injury. The Secretary of State may cause a formal public investigation to be made into the causes and circumstances of any explosion or accident subject to certain regulations. Such special report or reports of public inquiries may be made public if the Secretary of State think fit.

Arbitration.—Provisions are stated as to parties to arbitrations under the Act and modes of procedure; and directions are also given for the conducting of Coroners' inquests on deaths by accidents.

PART II. RULES.

General Rules.—1. An adequate amount of ventilation to be constantly produced, to render harmless noxious gases, so that the working places of the shafts, levels, stables, workings, and travelling roads shall be in a fit state for working and passing therein. The quantity of air to be registered once a month.

2. Where a fire is used for ventilation, the air, unless diluted, to be passed clear of the fire by a dumb drift.

3. Where a mechanical contrivance is used for ventilation, it is to be placed where it is not likely to be injured by an explosion.

4. Stations to be appointed at the entrance to the mine, or

parts of the mine, and a competent person to examine the mine beyond such stations before each shift, as to gas, ventilation, roof, and sides, and general safety; the inspections to be made with a locked safety lamp if gas has been found within 12 months; and the result to be recorded in a book. An inspection to be made also during each shift.

5. Examinations to be made every 24 hours of machinery, guides, head-gear, ropes, chains, and other appliances in use; and every week of the state of the shafts; and the result to be stated in a report book.
6. Places not in course of working to be fenced.
7. Workmen to be withdrawn if the mine be found to be dangerous, and not readmitted until a competent person has reported it safe.
8. Only a locked safety lamp to be used in or near a place where gas to a dangerous extent is likely to be; and no naked lights to be used between the place where such lamps are used and the return airway.
9. Safety lamps to be so constructed as to be safe against the current, although inflammable, usual in that part of the mine.
10. All safety lamps to be securely locked, and to be examined by a competent person before being taken into the workings, and not to be unlocked except at the lamp-station, or for firing a shot. No one, unless the authorised person, to have any contrivance for unlocking safety lamps. Means of striking a light for shot-firing to be in a closed chamber attached to the shot fuse.
11. Safety lamp stations not to be in the return air.
12. Explosive substances not to be stored in the mine, nor taken there otherwise than in cartridges, in a canister containing not over 5lbs., unless exempted by the Secretary of State. No more than one canister to be in use at one time. No iron or steel tool to be used in charging, and no coal dust to be used for tamping. No explosive to be forcibly pressed into a shot hole; no hole when charged to be unrammed; and no new hole to be bored within six inches of one that has missed fire.

In a mine using locked safety lamps, or which is dry and dusty, shots to be fired only by a competent person after examination and finding safe of places twenty yards around the shot. If gas was found at any of the preceding four examinations in a ventilating district, no shot to be fired there unless the place has been cleared of gas and reported safe, or unless the explosive cannot inflame gas; if the place be dry and dusty, all places within twenty yards' radius to be wet, or the explosive used to be flameless; if the dry and dusty place is, or is near, a haulage road, where mechanical power is or has been used, places twenty yards around to be wet, or the explosive flameless, and all workmen to be removed from the workings on the same level, except those firing the shot, and other necessary workmen not exceeding ten. "Ventilating district" means part of a mine having independent intake and return from a main intake and to a main return respectively. Seams of ironstone having no coal associated are exempted from the restrictions as to shot firing.

13. Places approaching dangerous accumulations of water not to exceed, for forty yards therefrom, eight feet in width; and bore holes, not less than five yards to be kept in advance and on each side.
14. Self-acting and engine planes on which persons travel, if exceeding thirty yards in length, to have means of signalling, and man-holes every twenty yards; or if there is no side room to stand, then every ten yards, unless the tubs are moved by endless chain or rope.
15. Horse-roads to have man-holes every fifty yards. Every steam engine room and boiler gallery to have two ways of access.
16. Refuge places to be kept clear.
17. Horse-roads to be high enough to save the animal from injury.
18. Disused and air shafts to be fenced.
19. Entrances to working, ventilating, and pumping shafts to be fenced; the fence to be removable under precautions.

20. Working and pumping shafts to be lined where the strata are unsafe.
21. The roof and sides of every travelling and working place to be made secure.
22. Workmen who timber their places to be supplied with suitable timber, convenient to their work. Sprags to be not more than six feet apart.
23. Workmen to have the option of using the downcast shaft when the upcast is a furnace shaft.
24. Machinery raising and lowering persons, to be under the charge of a man not under twenty-two years of age, who shall attend so long as any one is in the mine. Machinery used underground for conveying persons, to be under the charge of a male person not under eighteen years of age.
25. Working shafts, over 50 yards in depth, to have guides and means of communicating signals to and from the top and bottom, and intermediate places in the shaft.
26. The speed of winding up, with men on, to be not over three miles an hour, from a point in the shaft to be fixed by the special rules, unless there be a contrivance to prevent overwinding.
27. A sufficient cover overhead to be used when lowering or raising persons in any working shaft.
28. A single linked chain not to be used for lowering and raising persons.
29. Drums used in lowering and raising persons to have appliances to prevent slipping of the rope.
30. Machines lowering and raising persons to have an adequate brake on the drum shaft, and an indicator showing the position of the cage in the shaft.
31. The fly wheel and dangerous exposed parts of machinery to be fenced.
32. Each steam boiler to have a safety valve, steam gauge and water gauge.
33. A barometer and thermometer to be placed at the entrance to the mine.
34. Ambulance stretchers, splints and bandages to be kept for immediate use.

35. Wilful damage of appliances provided in terms of the Act is prohibited.
36. Directions given with a view to comply with the Act or special rules are to be observed.
37. Report books provided by the Act to be kept at the office of the mine, and to be open to the inspector or any workmen.
38. The workmen may appoint two practical miners once a month to inspect the shafts, underground works, and machinery, every facility to be given them for so doing; and the result to be entered in a book kept for the purpose, and reported to the inspector if any danger is apprehended.
39. No one to be allowed to work alone as a coal or ironstone getter, unless he has had two years' experience under a skilled workman, or has been employed two years in or about the face of the workings of a mine.

Special Rules.—Special Rules* to be established at every mine which, in the circumstances, may best prevent accidents and provide for safety and proper discipline. Such Rules, when approved by the Secretary of State, or, in the event of difference of opinion, when settled by arbitration, and signed by the inspector, to have the strength of the Act. The Special Rules may be amended from time to time.

An abstract of the Act and Special Rules to be posted up at the mine, and a copy to be supplied to all workmen free on application.

PART III.

The penalty for offences against the Act, where not expressly prescribed, is £20 for an owner, agent, manager, or under-manager, and £2 for another person. For offences wilfully committed, calculated to endanger the safety of persons or cause a dangerous accident, imprisonment for three months may be imposed.

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* See Appendix, p. 97.

Provisions follow as to legal procedure and application of fines explanation of terms, and other miscellaneous matters.

Existing Inspectors and Examination Boards are continued under the Act, and existing certificates are held to be equivalent to first-class certificates under the Act. Second-class certificates of service to be granted, on application to the Secretary of State, to those who satisfy him that for twelve months, within the five years before the passing of the Act, they were acting as under-managers in a mine.

The Acts of 1872, 1881, and 1886 are repealed.

Whatever opinion may be held as to whether Parliament was, or was not, over-cautious in the introduction of the various measures dealing with the working of mines, it is at least worthy of notice that each measure has proceeded from its predecessors by a process of growth and expansion, and that in no important particular has a provision in one Act had to be rejected in the next as inapplicable and futile. Moreover, the Legislature has refrained from making particular systems, or the use of particular appliances, compulsory; and when we consider the rapid advances that have been made in the application of the mechanical arts to mining, and the modifications and improvements in various details of underground working that have thereby been made practicable, we can the more readily see the propriety of such a course. The inquiries of the many Select Committees, and legislation following thereon, certainly gave an impulse to scientific inquiry and the application of safer and more satisfactory methods in the working of mines; but other agencies were springing up and working in the same direction, and bringing about in a more excellent way the ends aimed at, and the Mining Institute of Scotland has been not the least useful of these agencies. It is pretty generally agreed that the Act of 1887 is in touch with the times, embodying on the whole, so far as is desirable in a general Act, the results of the latest experience in scientific investigation and enlightened practical working. Notwithstanding all that has been done, accidents will happen, and valuable lives will be lost; and there are not wanting those who allege that legislation has failed, or is

behindhand so long as colliery catastrophes are possible. But it is not in the piling up of compulsory and restrictive measures alone, or even chiefly, that the end which all desire will be attained, but also in a more wide-spread and thorough knowledge of and regard for principles, scientific and moral, on the part of all concerned, by which means practice will be intelligently guided, and the best and safest methods carried out as matters of course.

APPENDIX

TO

MR JAMES BARROWMAN'S PAPER

ON

SCOTCH MINING LEGISLATION.

APPENDIX.

[The following Special Rules, framed by a Joint Committee of the Lanarkshire, Airdrie and Slamannan, Ayrshire, and Fife and Clackmannanshire Coalmasters' Associations, have been set up at the majority of the Collieries in Scotland with the view to being established in terms of the Act of 1887.

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THE COAL MINES REGULATION ACT, 1887,

50 and 51 Victoria, Cap. 58.

SPECIAL RULES

For the Conduct and Guidance of the Persons acting in the Management of this Mine, or employed in or about the same, to prevent dangerous accidents, and to provide for the safety, convenience, and proper discipline of the Persons employed in or about the Mine, in terms of Section 51, of "The Coal Mines Regulation Act, 1887."

INTERPRETATION OF TERMS.

In the Interpretation of these Special Rules, the following words shall have the following meanings, unless excluded by the subject or context:—"Agent" means any person appointed as the representative of the Owner in respect of any Mine, and as such superior to a Manager appointed in pursuance of the Act. "Manager" means the Certificated Manager under the Act. "Under-Manager" means the Certificated Under Manager under the Act. "Overman" means a person having charge of the Mine below the surface, or any part thereof, and the workers employed therein. "Miner" means any person employed in the Mine in the cutting, excavation, or removal of Coal, Ironstone, Shale, Fire-Clay or other minerals, metals, or materials. "Mine" includes division of the same in terms of the Statute, sec. 19. "Statute" means "The Coal Mines Regulation Act, 1887." Words importing singular number include the plural number. Words importing plural number include the singular number.

AGENT

1. The Agent, where one is appointed separate from the Owner, shall have, as representing the Owner, the care and direction of the Mine committed to his charge ; and it shall be his duty to take a general supervision thereof ; to see that the Manager attends to and performs his duties ; and generally to act as the Owner's Representative, and see that the Mine is conducted in conformity with the requirements of the Statute.

N.B.—*Copies of the Statute, Abstract thereof, and Special Rules, are supplied to the Agent on application.*

MANAGER.

2. Generally the Mine shall be under the control, management, direction, and supervision of the Manager, whose duty it shall be to carry out, and see carried out, the various provisions of the Act, so far as incumbent on him, or on those acting under his control and directions, and to see that sufficient materials and appliances are always provided for the proper carrying out of all necessary operations. He shall also appoint such competent persons as may be required for the purpose of carrying out the provisions of the Statute.

3. Where there is no Under-Manager, the Mine shall be under the daily personal supervision of the Manager.

N.B.— *Copies of the Statute, Abstract thereof, and Special Rules, are supplied to the Manager on application.*

UNDER-MANAGER.

4. Daily personal supervision of the Mine shall be exercised by the Under-Manager, if any ; and, in the absence of the Manager, he shall have the same responsibility, and be subject to the same liabilities as the Manager, under the Statute.

5. Where an Under-Manager also acts as an Overman, he shall likewise observe the rules applicable to an Overman.

N.B.—*Copies of the Statute, Abstract thereof, and Special Rules, are supplied to the Under-Manager on application.*

OVERMAN.

6. Subject to the control and direction of the Manager or Under-Manager, the whole operative details shall be under the

care and charge of the Overman. He shall see that the Workers of every class in their several departments discharge their duties; and shall receive and attend to all reports made to him as to the state of repair of the Air-Courses, Machinery, Mid-Walls, Trap-Doors, Roads, Ventilating Appliances, and working-places. He shall cause remedies to be provided where needed, and shall have power to hire and discharge Workers.

7. He shall see the General and Special Rules faithfully and vigorously enforced.

8. He shall measure at least once in every month the quantity of air in the respective splits or currents of the Mine, and enter the results in a book to be kept for the purpose at the Mine.

9. He shall have under his immediate and special charge the Shaft Guides or Conductors, Pumps, and relative Fittings, all of which he shall keep safe and efficient; shall once at least in every week examine the state of the Shafts by which persons ascend or descend, and shall make a true report of the result of such examination, and every such report shall be recorded without delay in a book to be kept at the Mine for the purpose, and shall be signed by him.

10. He shall have charge of the Ambulances or Stretchers, Splints, and Bandages kept at the Mine in terms of General Rule No. 34.

11. He shall, without delay, report to the Under-Manager, Manager, Agent, or Owner any matter or thing coming under his notice necessary to be observed or carried out with a view to compliance with the General or Special Rules, which he cannot himself perform.

N.B.—*Copies of the Statute, Abstract thereof, and Special Rules, are supplied to the Overman on application.*

PITHEADMAN OR BANKSMAN.

12. The Pitheadman during his shift shall, subject to the control and supervision of the Manager or Under-Manager, have charge of the Workers employed about the Pithead, and every such worker shall act under his directions. He shall observe that, at all times, there is sent down the Pit a stock of timber for Props and other necessary purposes, for the use of

the Miners and other Workers, and report to the Manager or Under-Manager if at any time he observes or has it reported to him that there is a deficiency of such timber or other articles. He shall superintend and direct the safe removal from the Cage of all loaded Hutches arriving at the Pithead, and see to the safe replacing of the return Hutches on the Cage. He shall be in attendance in the morning, or at such other time of the day as the Miners' shift commences, and shall see that no person is allowed to go upon the Cage until the Engineman has ascertained and reported the safety of so doing, in terms of Special Rule No. 28. He shall regulate the number of persons descending at a time, and take care that not more than *four* to a Cage holding one Hutch, *eight* to a Cage holding two Hutches, *twelve* to a Cage holding three Hutches, or *sixteen* to a Cage holding four Hutches, shall ride on such Cages respectively, and no one along with a Hutch or on a Cage without a sufficient cover.

13. He shall see that Sections 7 and 8 of the Statute, as to the employment and registration of boys, girls, and women, are enforced, and specially that no boy, girl, or woman shall be employed in moving railway waggons. He shall not permit any one not employed therein to descend the Pit without the permission of the Owner, Agent, Manager, or Under-Manager.

14. He shall see that the Cages are in proper order, and that no defective Hutches are sent down the Pit.

15. He shall once at least in every twenty-four hours carefully examine the state of the external parts of the machinery, the state of the Guides and Conductors of the Shafts, and the state of the Headgear, Ropes, Chains, and other similar appliances of the Mine which are in actual use above ground; and also so far as exposed to his observation, except in so far as such examination is directed to be made by the Winding Engineman or other person specially appointed, and shall make a true report of the result of such examination, and every such report shall be recorded without delay in a book to be kept at the mine for the purpose, and shall be signed by him; and if he discover or be informed of any defect or weakness likely to produce danger, he shall stop the raising or lowering of persons or materials until such defect or weakness be remedied. He shall communicate to

the Manager, Under-Manager, or Overman any necessity for a skilled person being employed to rectify any such defect or weakness. He shall also be careful to prevent the fall of any stone, coal, or other substance into the shaft from the surface.

16. He shall see that the Shaft is securely fenced during and at the close of the shift, and that all unnecessary fires and lights are extinguished.

17. He shall only allow the Cage empty, or with persons in it, to descend when persons are being raised on the other Cage.

18. In the absence of a "Weigher" specially appointed for the purpose, the Pitheadman shall act as Weigher, and see that all Tubs or Hutches are properly filled with the "Mineral contracted to be gotten," and that the proper deductions are made in respect of Stones or substances other than the Minerals contracted to be gotten, or in respect of Tubs, Basket, or Hutches improperly filled—in terms of Section 12 of the Statute.

N.B.—*Copies of the Abstract of the Statute and Special Rules are supplied to the Pitheadman on application.*

WEIGHER.

19. Where a person is specially appointed as Weigher, it shall be his duty to attend to the matters embraced in Special Rule No. 18.

WINDING ENGINEMAN.

20. The Engineman at the Pithead shall, during the hours of his shift, remain in charge of, and so near his engine, as at all times to have it completely and entirely under his control.

21. He shall attend for the purpose of lowering and raising persons in the Mine during the whole time that any person is below ground in the Mine.

22. He shall see that the Engines and Boilers are always in good working condition, that the Pumps and whole Machinery and Gearing connected with his Engine are in a safe and effective state, and that any Fly Wheel, or exposed and dangerous part of the Machinery, is securely fenced.

23. He shall, once at least in every twenty-four hours, examine the state of the Machinery, and the state of the Head Gear, Pulleys,

Ropes, Chains, and other similar appliance of the Mine which are under his charge, and shall make a true report of the result of such examination; and every such report shall be recorded, without delay, in a book to be kept at the mine for the purpose, and shall be signed by him.

24. He shall have charge of the Furnacemen connected with the Engine, where these are employed, and be responsible for the regularity with which Steam is kept up, and for the proper state of the Boilers.

25. After a boiler is cleaned or repaired, he shall thoroughly examine it internally, and be satisfied that it is in a fit state to work before the steam is again raised.

26. He shall have steam raised, and the engine and machinery in working order, in time to allow the Firemen, Roadsmen, Overman, Under-Manager, or Manager to descend the Pit to examine the condition of the Mine, before the Miners' or other Workers' shift shall commence.

27. He shall thoroughly acquaint himself with, and shall watch and attend to, the various signals made for raising or lowering the Cage, whether laden with persons or materials, or when empty. He shall carefully and exactly stop the Cage at the landing places. He shall observe the indicator attached to the machinery, showing the position of the load in the shaft, and manage the Brake connected with the Engine. He shall farther attend to and see that the Indicator shows the position of the Cage in the Shaft, and that the Indicator, Brakes, and other fittings of the Engine, and any Steam and Water Gauges, and Safety Valves attached to the Steam Boilers, are kept in good order.

28. Before allowing the descent of Workers into the Mine on any morning, or after the Engine or Cages shall have stood for the space of two hours or longer, the Engineman shall be bound to run each Cage, at least once, from the pit-head to the pit-bottom, to ascertain whether everything is right, and if any defect shall be discovered, he shall stop the Engine, and shall not, on any pretext, allow the descent of Workers until the matter has been reported to the Manager, Under-Manager, Overman, or person in charge, who shall direct what remedy shall be necessary.

He shalll not allow any Worker to descend the pit until the Fireman shall have reported the safety of so doing.

29. He is prohibited from allowing any person whatever to interfere with the Engine in any way while being wrought, and from allowing or permitting any person other than those authorised by the Owner, Agent, Manager, Under-Manager, or Overman to enter or remain in the Engine-house.

30. If the winding apparatus is not provided with some automatic contrivance to prevent overwinding, he shall see that the Cage, when men are being raised, is not wound up at a speed exceeding three miles an hour, after the Cage has reached a point in the shaft not less than the circumference of the drum from the surface.

31. He shall attend to all Signals, and make the necessary Return Signals, specified in the Code of Signals appended to the Special Rules.

N.B.—*Copies of the Abstract of the Statute and Special Rules are furnished to the Engineman on application.*

GENERAL ENGINEMEN.

32. The Rules relating to the Winding Engineman shall, in so far as applicable, apply to Enginemen in charge of Haulage, Pumping, and other Engines and Ventilating Fans.

33. The Engineman in charge of a Ventilating Fan shall see that it is kept going at the speed required by the Manager or Under-Manager, and shall at once acquaint him of any defect, so that, if necessary, the men may be withdrawn from the Mine.

FURNACEMEN.

34. Subject to the control of the Manager, Under-Manager, or Overman, Furnacemen shall act under, and obey the directions of, the Enginemen. If they shall observe any derangement or defect in the boilers, their connections or fittings, they shall immediately report the same to the Enginemen in charge thereof.

FIREMEN.

35. It shall be the duty of the Fireman or Firemen, if more

than one, in their respective divisions and shifts, to perform the duties of inspecting not more than two hours immediately before the commencement of each shift, the Roadways, Working-Places, and every part of the Mine situated beyond the Station, or each of the Stations, appointed at the entrance to the Mine, or different parts of the Mine, in terms of the Statute, and in which Workmen are to work or pass during that shift, and to ascertain the condition thereof, so far as the presence of gas, ventilation, roof and sides, and general safety are concerned. The above inspection shall be made with a locked safety lamp, unless inflammable gas has not been found within the preceding twelve months, which it shall be the duty of the Manager or Under Manager to ascertain and intimate to the Fireman, and in every case where the mine is worked with safety lamps, for the purpose of this rule, two or more shifts, succeeding one another without any interval, are to be deemed one shift. In making the above inspection, the Fireman shall mark with chalk the day of the month upon the face of each Working Place, as 1, 5, 10, 25, or other numbers, as the case may be.

36. In the event of the Fireman finding either the ventilation or roof and sides defective, or anything affecting the general safety of the Mine between the pit-bottom and the Station underground, he shall at once return to the pit-bottom and report, so as to prevent persons descending.

37. He shall record without delay in a book, to be kept at the mine for the purpose, and accessible to the workmen, where noxious or inflammable gas (if any) was found present, and what defects (if any) in roofs or sides, and what (if any) other source of danger were or was observed in his inspection before commencing work, and such Report shall be signed by, and, so far as the same does not consist of printed matter, shall be in the handwriting of the Fireman who made the inspection.

38. He shall make an inspection similar to that provided for in Special Rule No. 35. in the course of each shift, of all the parts of the Mine in which workmen are to work or pass during that shift; but it shall not be necessary to record a report of the same in a Book, as provided for by Special Rule No. 37, provided that in the case of a Mine worked continuously throughout the

twenty-four hours by a succession of shifts, the Report of one of such inspections shall be recorded as required by Special Rule No. 37.

39. He shall be careful to ascertain that every part of the Mine and Roadways, so to be examined, is free from fire-damp, choke-damp, and other impurities, and is safe for Workers to enter and to work therein; and in case fire-damp or other impure air shall be discovered in any working-place, road, or level, the Fireman shall, in the first instance, thoroughly clear the same of such impurity—if that can be done easily—and shall thereupon report to the Miners, and other workers, that the same is safe; but if the impurity cannot be readily or at once cleared out, the Miners and Workers shall not be permitted to enter any such working-place, road, or level, or—if the accumulation be dangerous—into any place ventilated with the current of air which has left that place, until the impure air shall have been, by further appliances, entirely dispelled. He shall prevent Miners or other Workers entering the roads or working-places until a report shall have been made that they are safe. If no fire-damp, choke-damp, or other impurity shall be discovered, or suspected to remain after such inspection, the Fireman shall make report to the Miners and Workers, and allow them to proceed to work.

40. If the Fireman shall encounter falls from the roof, in any of the roads which he requires to traverse, or in working places under the care of the Miners, he shall not proceed farther in the direction of such falls, so as to pass under the broken roof, but shall endeavour, cautiously, to ascertain if there be any accumulation of fire-damp or other impurity, in, about, or beyond the falls, so that the safest way of clearing the same may be learned, and shall proceed elsewhere through the Mine when necessary to examine the unobstructed parts thereof, and to complete his inspection; whereupon the Fireman shall report to the Manager, Under-Manager, or Overman the state of the falls, and whether free from impurity, so that the necessary directions may be given for having the same cleared away, and the roof secured; and, until this shall be done, no Miner or other Workman shall be at liberty to proceed near, or be under, the broken roof, unless employed in remedying the same.

41. In case, from any cause, the operations of the Mine shall have been discontinued for an unusual length of time, and thereafter resumed, no Worker shall be allowed to descend the shaft until the Manager, Under-Manager, Overman, or Fireman shall have first descended and reported on the state of the workings; and in discharging this duty the Manager, Under-Manager, Overman, or Fireman must proceed with great caution, and shall not go further into the workings than he, from his own experience, shall deem safe; and in case there are reasonable grounds for apprehending the presence of impure air, he shall return to the pit-head until precautionary measures can be applied to restore the proper ventilation of the Mine.

42. Without prejudice to the foregoing Rules, it shall also be the duty of the Fireman to fence or cause to be fenced all entrances in terms of General Rule No. 6; as also, in going his rounds, to observe and report to the Manager, Under-Manager, or Overman upon the following matters embraced in the General Rules :—

(1) Any deficiency in the amount of ventilation, as provided for in terms of General Rule No. 1.

(2) Any attempt on the part of Workmen to violate General Rule No. 4 as to going beyond the appointed Station.

(3) Any violation of the terms of General Rule No. 12 as to use of explosives.

(4) Any failure to keep clear Manholes in terms of General Rule No. 16.

(5) Any failure to make secure the roof and sides of Travelling-roads and Working-places, under General Rules, Nos. 21 and 22.

(6) Any violation of General Rule No. 35 as to the damaging of Fences, Signals, &c.

43. It shall be the duty of the Fireman, when he discovers that any part of the Mine is dangerous from the presence of noxious gases, or from any cause whatever, to require the Workmen to *withdraw* from the Mine, or the part thereof so found dangerous, in terms of General Rule No. 7, and all Workmen shall be subject to his orders in respect of this matter; and whether the Workmen are withdrawn by himself or the Roadsman, he shall

thereupon, as the "competent person appointed for the purpose, inspect the Mine, or such parts thereof as are dangerous, in manner and to the effect provided for in said General Rule, and make a report as therein provided. He shall also fit up bratticing where required, of suitable height and length, so that air may be at all times conveyed from the principal air-courses for the use of the Workmen.

44. It shall be the duty of the Firemen to see that the Miners are attending to the security of the roofs and sides of their working-places, and in case of finding that any Miner is failing to secure his working-place, by propping the same, and setting sprags or holing props, or otherwise, to point out to such Miner any such failure, and direct him to perform such repairs as may be necessary to render the place secure, and if he should refuse, to require him and his assistants to remove from such working-place.

45. It shall likewise be the duty of the Fireman or Firemen in their different departments or shifts (unless some other official shall be specially appointed), where explosives are being used, to act as the "competent person," in terms of General Rule No. 12, to ascertain the state of inflammable gas, dryness, or dust, to prevent explosives being used otherwise than as there provided for, and to fire the shots in terms of General Rule No. 12 (f).

46. Where Firemen also act as Roadsmen, they shall likewise observe the Rules applicable to Roadsmen.

N.B.—*Copies of the Abstract of the Statute, and Special Rules, are furnished to the Fireman on application.*

ROADSMEN.

47. The Roadsmen, in their different divisions and shifts, if more than one, shall, at least daily, make careful inspection of the whole Roadways from the Pit-Bottom throughout the Mine where men are to work or pass, and shall keep the same free from all obstructions, and of the height and width necessary for proper passage and for ventilation. They shall repair and remedy all damages and defects in the roads of the Mine, and examine, put, and keep in proper condition all Trap-doors, and see the Regulations enforced that the same are kept closed; and, wherever

practicable, endeavour to make and keep such Trap-doors self-acting. They shall place sufficient Trap-doors wherever the progress of the operations of the Mine renders these necessary.

48. They shall, once at least in every twenty-four hours, examine the state of the external parts of the Machinery, the state of the Guides and Conductors in the Shaft, and the state of the Ropes, Chains, and other similar appliances of the Mine which are in actual use below ground, and shall make a true Report of the result of such examination; and every such Report shall be recorded without delay in a book to be kept at the Mine for the purpose, and shall be signed by the Roadsman making the examination.

49. They shall also lay rails in the roads where requisite; and, in the absence of the Manager, Under-Manager, or Overman, receive all reports or communications from the Miners and other workers as to falls and defects in the roads, roofs, and buildings, and proceed to and repair or remedy the falls and defects.

50. They shall stop the passage of persons and materials through or under defective roads, roofs, or places until the necessary repairs shall have been executed. They shall be entitled to demand and receive information concerning any interruption in the ventilation, or of any other cause of danger, and immediately communicate with the Manager, Under-Manager, or Overman, and shall aid and assist in the rectification and remedy of the same, and shall when so employed be permitted to use only locked safety lamps, where there is likely to be any such quantity of inflammable gas as to render the use of naked lamps dangerous. When safety lamps are in use, all other lighted combustible substances are forbidden to be used in the course of such operations.

51. It shall be the special duty of the Roadsmen in their different divisions, if more than one, to observe that suitable timber is provided at the working place, gate-end, pass-bye, siding, or other similar place in the Mine, convenient for the workmen, and to report to the Manager, Under-Manager, or Overman, if they shall observe any want of such timber. For the purpose of carrying out this Rule, Roadsmen are empowered to call upon Drawers, and all other persons employed in haulage, whether employed by the Owner or Miner, to convey such timber

from the Pit-bottom, or other place of general delivery, to such working place, gate-end, pass-bye, siding, or other similar place.

52. The Roadsmen shall report to the Manager, Under-Manager, or Overman any instances of neglect on the part of Miners in not carrying forward their faces or walls in accordance with the plan pursued in working the Mine. They shall also examine and report to the Manager, Under-Manager, or Overman instances of neglect and acts of carelessness on the part of the Miners or Brushers, in failing to remove or in not removing with proper caution the strata necessary to be removed to form roads, or in not carrying forward the brushing with sufficient regularity, and of the proper dimensions, or in leaving the brushing with loose or hanging stones in and about the strata "brushed."

53. As removing falls from the roofs and sides of roads and air courses, and repairing defects therein, are within the Roadsmen's duties, and as they are charged with the maintenance of all roads and passages in the Mine, they are enjoined to proceed with the greatest caution—both for their own safety and the successful execution of their duties. In these operations they must therefore be careful, and are required to prevent all other workers coming near any defective places, or interfering with them when at work. They are required to undertake no repairs of unusual magnitude or danger without sufficient assistance, and until provided with every necessary material, which will be supplied on application to the Manager, Under-Manager, or Overman.

54. Without prejudice to the foregoing directions, it will be the special duty of the Roadsmen to observe the matters embraced in the following Regulations :—

(1) Upon discovering that any part of the Mine is dangerous, in terms of General Rule No. 7, to withdraw therefrom any Workmen therein employed (which Workmen will be subject to the Roadsman's orders to that effect), and report the state of matters to the Manager, Under-Manager, Overman, or Fireman.

(2) To report to the Manager, Under-Manager, or Overman, where they observe any violation of General Rule No. 12 as to use of explosives.

(3) To attend to General Rule No. 14 as to signalling and man-holes for travelling places worked by machinery.

(4) To attend to General Rule No. 15 as to manholes for other travelling roads.

(5) To see that every manhole or place of refuge is kept clear, and that no person places anything therein, in terms of General Rule No. 16.

(6) To attend to General Rule No. 17 as to dimensions of travelling roads.

(7) To examine the roof and sides of every travelling road at least daily, and see that the roofs and sides are safe, in terms of General Rule No. 21.

(8) He shall see that every fly-wheel and all exposed and dangerous parts of the machinery below ground are kept securely fenced in terms of General Rule No. 31.

(9) To report any damage to any fence, casing, lining, means of signalling, or otherwise, that may be observed, in terms of General Rule, No. 35.

55. Generally, the Roadsmen shall observe and fulfil the whole duties falling within their departments under the Statute.

N.B.—*Copies of the Abstract of the Statute and Special Rules are furnished to Roadsmen on application.*

BOTTOMER AND SIGNALMAN.

56. The Bottomer shall attend, during his shift in the Mine, to regulate the number of persons who shall ascend on the cage at a time—to keep order among the Drawers, Drivers, and Haulagemen arriving with loaded hutches at the pit-bottom—to see that the loaded hutches are carefully placed on the Cage and secured—to make the appointed signals necessary for regulating the ascent of persons and materials—to examine and report to the Manager or Under-Manager on the state of the Signal Apparatus, and of the Hutches used in the Pit, and of the Cages wrought in the Shaft; and also on the state of the Guides or Conductors in which the Cage moves, so far as these are under his observation.

57. He shall see that all entrances between the top and bottom, including the sump, if any, of every working, ventilating, or pumping shaft, are properly fenced.

58. He shall, where there is no Furnaceman specially appointed, attend to and keep in proper order the Ventilating Furnace in the Pit.

59. The Bottomer shall attend to and answer the signals made by the Engineman from the surface, and not allow any person to make signals while he, the Bottomer, is on duty.

60. He shall not suffer more than *four* persons at a time to ascend the shaft in a Cage holding one hutch, *eight* in a Cage holding two hutches, *twelve* in a Cage holding three hutches, and *sixteen* in a Cage holding four hutches. He shall not allow any person to ascend along with a Hutch, whether empty or loaded, or in a Cage without a sufficient cover; and he shall only allow the Cage empty or having persons in it to ascend while persons are being lowered on the other Cage.

61. In the absence of the Bottomer, the Fireman, Roadsman, or some other qualified person appointed by the Manager, Under-Manager, or Overman, shall make the necessary signals from the Pit-bottom, and receive and attend to the signals sent from the surface.

62. The Bottomer, or such person acting in his absence, shall make and observe the signals specified in the Code of Signals appended to the Special Rules, and when persons are about to ascend, he shall not allow any person to go on the Cage until he receives the counter-signal that all is ready.

63. No deviation from the signals specified in the Code shall be permitted on any account. The ascending signals shall not be made until the Cage with its load, whether of men or materials, is securely placed, and everything is ready for the ascent.

64. The Bottomer shall not leave his post at the Pit-bottom until the whole workers of his shift shall have ascended the shaft.

65. He shall prevent, or report to the Manager, Under-Manager, or Overman, upon any neglect or violation of the General Rules, or Special Rules, coming under his observation.

N.B.—*Copies of the Abstract of the Statute and Special Rules are furnished to the Bottomer on application.*

MINERS AND OTHER WORKERS.

66. Miners and other Workers are, and shall be, generally subject to the control and orders of the Agent, Manager, Under-Manager, and Overman. They shall also be subject to any directions which the Pitheadman, Fireman, Roadsman, or Bottomer may give in their respective departments, for the purpose of preventing them from infringing, or of causing them to comply with, any of the provisions of the Statute or of the General or Special Rules.

67. Miners and other Workers shall not proceed into travelling roads or working places until it shall have been reported to them by the Fireman, Roadsman, or other person appointed for the purpose, that such travelling roads or working places are safe to be entered.

68. Until such report or intimation of safety is so made, no Miners or other Workers shall pass beyond the station appointed; and, if no other place or station has been appointed, they shall always understand that the Pithead is the station at which they are required to wait the necessary examination and report.

69. Notwithstanding and without prejudice to the inspection by the Fireman or other person appointed, Miners are required to examine their own working places before commencing to work at the beginning of their shift, and after any interruption of work during the shift, particularly after firing a shot, and in case of finding from the condition of roofs and sides or otherwise that such working place is not in a state of safety, they are required to withdraw themselves and their assistants therefrom until proper remedies are applied.

70. If, while at work, or at other time, any Miner or Worker shall cause, discover, or be informed of the existence of any obstruction in the ventilation, or stagnation or impurity in the air of the Mine, or the existence of any defect in the walls, roofs, or in any other parts thereof, he shall be bound to give instant information of the circumstances to the Manager, Under-Manager, Overman, Fireman, or Roadsman, so that these defects may be remedied and danger therefrom averted.

71. Miners are expressly forbidden to go into or improperly

near any place throughout the whole Mine where danger is known or suspected to exist. They are forbidden to continue at any part of a face where a sudden outburst of fire-damp shall happen, or where danger from any cause whatever shall apparently threaten, until the same shall have been examined and reported safe, or the impurity or other cause of danger removed.

72. Miners and other Workers shall not ride on hutches, ropes, or chains, without the permission of the Manager.

73. Whether the operations shall be conducted by the "Long-Wall" or "Stoop-and-Room" system, suitable timber being provided at the working place, gate-end, pass-bye, siding, or other similar place in the Mine convenient for the Miners, the same shall be set up by the Miners in their working places, where the roof and sides require to be secured by them. The timber, and any necessary sprags or gibs, shall be set up at such times, in such number, and at such points, within the working limits, as shall from time to time be necessary, but the distance between the sprags or holing props, where they are required, shall not exceed six feet, or such less distance as may be ordered by the Owner, Agent, or Manager.

74. But besides being bound to prop and secure according to their own skill and experience, Miners are required to place props, sprags, or holing props within their working places in such manner as the Fireman, or other person authorised to that effect, shall deem necessary and shall direct, for the safety of the Workers and the mine.

75. Miners shall prop and secure the roof and sides of the places at which they may be employed in the "long-wall" system to the distance of *twelve* feet from the face, and in the "stoop-and-room" system to the distance of *fifteen* feet from the face. When employed to remove "stoops," Miners shall prop and secure the roof and sides in the cut or place in which they are working. All such places shall be deemed "Working Places" under these Rules.

76. If, from accident or any other cause, Miners are at any time unable to find a sufficient supply of timber at the place appointed, they are expressly forbidden to remain in their working places.

77. The special attention of Miners and other Workers is

directed to General Rule No. 12 as to use of explosives below ground. They shall be guided by the instructions given by the Firemen relative thereto.

78. No person not employed as a coal or ironstone getter at the passing of the Statute (16th September, 1887), shall work alone as a coal or ironstone getter in the face of the workings until he has had two years' experience of such work under the supervision of skilled workmen, or unless he shall have been previously employed for two years in or about the face of the workings of a Mine, all as provided in General Rule No. 39. Miners and other Workers shall report any violation of this Rule to the Manager, Under-Manager, or Overman.

DRAWERS, DRIVERS, HAULAGEMEN, AND OTHERS.

79. Drawers, Putters, Drivers, and Haulagemen shall not be permitted to approach, or to enter the Roads or Working Places until the Miners shall have been allowed to proceed thither to work. They shall carefully convey their loaded hutches to the Pit-Bottom, Siding, Wheel, Chain, or Rope, as the case may be; and when the hutches are brought to the Pit-Bottom, they shall only be pushed forward under the control of the Bottomer. All Drawers, Putters, Drivers, and others shall be subject to the orders of the Roadsmen in carrying out Special Rule No. 51 as to the conveyance of timber.

80. Drivers shall not ride on horses or other animals below ground; and they shall report to the Roadsman any case in which a travelling road shall not be of sufficient dimensions to allow horses, or other animals under their charge, to pass without rubbing against the roof or timbering.

81. Drivers, Haulagemen, and persons in charge of inclined or engine planes shall not allow anyone to ride on Hutches, empty or loaded, without the special permission of the Manager.

82.—Benchers, Hangers-on, or other persons employed in connection with inclined or engine planes, shall control the putting forward and coupling of Hutches, and the attaching of the Chains or Ropes thereto. They shall make and attend to the Signals, and shall prevent anyone from approaching or travelling

on self-acting inclined planes on which Hutches are in motion. They shall stand clear of Hutches in motion, so as to avoid danger from breakages or runaways.

BRUSHERS AND REDDSMEN.

83. Brushers and Reddsmen shall, in the formation of roads, remove from the strata as much thereof as shall make them of the height and width required for the purposes of the Mine, and shall carefully build up the side walls, and properly remove or stow away surplus material. In detaching strata, and in the use of explosives for blasting, great caution (and attention to the General Rule No. 12) must be observed, and every fragment of stone shattered or unloosed shall be taken down, or otherwise properly secured. If, in the course of their operations, Brushers and Reddsmen shall expose a "lipe," or joint, in any of the strata, indicating the probability of a fall at that place, or if a "blower" shall be opened, or an accumulation of gaseous substances be encountered among the metals, or if they shall observe any other cause of danger, they shall report the circumstance instantly to the Manager, Under-Manager, Overman, Fireman, or Roadsman, and means shall be taken by the Brushers and Reddsmen, in the meantime, to secure the "lipe;" but if the accumulation of impure air shall be so considerable as to render it at all hazardous to continue brushing or building farther, until means shall have been taken to overcome and disperse the same, the Brushers and Reddsmen shall cease work, and shall be careful not to approach such places unless accompanied by the Fireman or Roadsman.

84. In brushing and building drawing roads towards faces, Brushers and Reddsmen are required to make their brushing and building regular and continuous, keeping pace with the progress of the working faces, so that the side buildings may be carried in, and the road formed, at a convenient distance back, simultaneously with the excavation of coal or other minerals.

DOOR-KEEPERS.

85. Persons employed in keeping Trap-doors for the production or promotion of ventilation in the Mine, shall, during their shifts, remain continually at the posts assigned them, and carefully

observe the directions they receive from the Manager, Under-Manager, Overman, Fireman, or Roadsman, as to the opening and shutting of such doors, either on the occasion of Workers or Hutches passing through the same or at the beginning or end of the shift.

CLERKS AND OTHERS.

86. Every Clerk, or other person, employed and instructed to keep any Register, in terms of the Statute, shall be bound to make the necessary entries, so far as materials are furnished to him for that purpose.

SAFETY LAMPS.

87. The Lamp-Room where the Safety Lamps are examined, cleaned, and repaired shall be on the surface. The Lamps shall be lighted on the surface before being taken into the mine, and the position of the Underground Lamp Stations for re-lighting the Lamps shall be fixed from time to time by the Manager or Under-Manager ; but shall not be in the return air.

88. In any Mine or part of a Mine in which Safety Lamps are required to be used :—

(1) No Safety Lamp shall be used until it shall have been examined at the appointed Lamp Station immediately before it is taken into the workings for use, by the Under-Manager, Overman, Fireman, or other person appointed for the purpose by the Owner, Agent, or Manager, and ascertained to be in safe working order, and securely locked in terms of general rule No. 10.

(2) A Safety Lamp shall not be unlocked except either at the appointed Lamp Station, or for the purpose of firing a shot in conformity with the provisions hereinafter contained.

(3) A person, unless he has been appointed either for the purpose of examining Safety Lamps, or for the purpose of firing shots, shall not have in his possession any contrivance for opening the lock of any Safety Lamp.

(4) A person shall not have in his possession any lucifer

match or apparatus of any kind for striking a light, except within a completely closed chamber attached to the fuse of the shot.

(5) A naked lamp or light shall not be used; and

(6) A person shall not smoke or have in his possession any pipe for smoking, cigar or cigarette.

89. Every person immediately after receiving a Safety Lamp shall examine it and see that it is in safe working order and securely locked.

90. In case any accident should happen to a Safety Lamp while in use, whereby it is rendered unsafe, the person using it shall at once extinguish the light by drawing the wick down within the tube with the pricker, or other safe means, and return it to the Lamp Station for examination and repair.

91. Every person using a Safety Lamp shall take proper care of it, and shall not hang it within the swing of any tool.

92. If any person using a Safety Lamp requires to have it opened or re-lighted, he shall take or send it to the Lamp Station to be opened, re-examined, repaired, or re-lighted by the person appointed for the purpose.

93. The Manager, Under-Manager, Overman, Fireman, Roadsman, or Bottomer is authorised to examine Safety Lamps in terms of General Rule No. 10, without prejudice to the appointment of any other competent person for that purpose.

MISCELLANEOUS REGULATIONS.

94.—If, in proceeding to their working places or in travelling along any formed road, or other part of the works, Miners, Drawers or other Workers shall meet with or see any fall from the roofs, or shall observe any dangerous place in the roofs, walls, or elsewhere in their progress, they shall not pass the same, but shall instantly report the occurrence to the Manager, Under-Manager, Overman, or Roadsman; and Miners, Drawers, and other Workers shall not return past the fall or dangerous place until the same shall have been made secure, which it shall be imperative on the Manager, Under-Manager, Overman, or Roadsman to have made secure forthwith.

95. As a matter of common safety, Miners, Drawers, and all

other Workers, who shall observe, or who shall come to the knowledge of, any damage to, or deficiency in, any road, roof, air-course, or permanent or temporary brattice, or in the shaft, buildings, furnace, or other appliance or work, devised for making, maintaining, and promoting the effective ventilation of the mine, or of any defect or flaw in the cages, ropes, or chains, machinery and gearing, used in or about the Mine, whereby the sufficiency thereof may be impaired, shall be bound instantly to make known such damage or deficiency to the Manager, Under-Manager, Overman, Fireman, Roadsman, or other person in charge, so that the same may be forthwith repaired or rectified.

96. If a shot has been lighted and does not explode, no person shall enter the place where it was lighted until thirty minutes shall have elapsed.

97. No Miner, or other Worker, shall be permitted to introduce into the Mine any person employed by him, or any stranger, on any pretence, without the consent of the Owner, Agent, Manager, Under-Manager, or Overman.

98. Every Miner or other person who shall be the immediate employer of any boy shall be bound to see that he is registered in terms of the Statute, and that such boy leaves the Mine when his period of work has expired.

99. Miners, Drawers, and all others who shall have occasion to pass through any Trap-door, shall thereupon closely shut the same, and shall on no account leave it open. On discontinuing work at the end of a shift, care must be taken by every Worker closely to shut all Trap-doors, and thereby prevent the proper current of air necessary for ventilation from being diverted.

100. All Workers are expressly forebidden to throw into, deposit, or leave coals or other minerals, wood, stones, or rubbish, or materials of any kind, in any air-course or road, so as to interfere with, or hinder, the air passing into and through the Mine, or to place anything in any Manhole.

101. All Workers are prohibited from entering or remaining in any place throughout the whole Mine where not absolutely required by duty to be at the time; and on no account shall they proceed through any fence, or pass any Notice, erected to indicate that danger exists.

102. Miners and all others are prohibited from knowingly or wilfully defacing or removing marks which may be made in any part of the workings for the guidance of the Workers and others in their operations. All Workers are forbidden to displace, injure, or damage, in any way, the stoops, props, hutches, rails, or any part of the machinery, gearing, and apparatus.

103. All Workers are enjoined to exercise the greatest care in trimming their lamps underground, to extinguish the old wicks and any lights used in the operation. Workers who are leaving work are forbidden to remove the wicks from their lamps until after they have reached the surface.

104. Meetings of Miners, or other Workers, in a body, underground or at the pit-bank, are strictly prohibited.

105. No person descending or ascending the shaft shall enter or leave the Cage while it is in motion, or until it shall have stopped at the landing place ; and no one shall enter the Cage in excess of the regulation number, or when objected to by the Pitheadman or Bottomer.

106. The Manager is empowered to search the pockets and clothing in the Mine of any Worker employed therein, when and as often as he may think proper ; and, in the event of anything being found in such pocket or clothing, or in the apparent keeping of any Worker, which in the opinion of the Manager is calculated to endanger the safety of anyone employed in the Mine, or is an apparent infringement of any of the Special Rules, to take possession thereof and detain such Worker until he can be given into custody.

107. No person shall be permitted to enter, or to continue in the Mine, while in a state of intoxication.

108. No person having special statutory duties to perform shall absent himself from work, except in case of illness (of which due notice shall be given,) without the consent of the Manager, Under-Manager, or Overman.

109. In the event of any of the instructions or rules herein set forth being neglected, whosoever may know of such neglect shall instantly inform the Manager, Under-Manager, or Overman thereof.

110. The Manager and other Officers of the Mine, and all

persons in the Mine, shall afford every facility for the inspection of the Mine on behalf of the Workmen, in terms of the General Rule No. 38; and the persons making this inspection shall comply with the Special Rules as far as applicable. The persons appointed on behalf of the Workmen to inspect the Mine shall forthwith make a true report of the result of the inspection, and that report shall be recorded in a book to be kept at the Mine for the purpose, and shall be signed by the persons who make the inspection.

SUPPLEMENTARY SPECIAL RULES.

For Pits or Mines in course of Sinking or Re-Sinking.

111. The Engineman shall not leave the Engine while it is in motion, and shall, previous to the landing of the Kettle, Barrel, or whatever may be in course of descent, at the bottom, give a signal to the man working there, and wait for a return signal before completing the lowering to the bottom.

112. The Engineman shall immediately before shots are to be fired ascertain that the Kettle or Barrel is in the proper position, and that all is ready at once to draw away on receipt of the signal to do so.

113. The Pitheadman shall not leave the Pithead when workers are ascending or descending the shaft.

114. The Pitheadman shall in all cases steady the Kettle, Barrel, or anything about to be sent down, before it leaves the surface, and see that all stones, bricks, or other small materials are kept below the level of the top of the Kettle or Barrel; that no stone, brick, or loose material is sticking to the bottom of the Kettle or Barrel; and that all tools, gear, and timber are properly secured when being sent down the shaft.

115. The Pitheadman shall see that in every case the Kettle or Barrel is lifted off the Settling-Board by the Engine, and is steadied into the Pit.

116. The Pitheadman shall see that no Rails are laid up to the mouth of the Shaft without some provision being made to prevent the Waggons being pushed into the Shaft.

117. The leading Sinker shall descend in the first Kettle in each shift and ascend in the last.

118. The leading Sinker in each shift shall have full charge of the sinking operations, and shall once in every shift, or oftener if necessary, examine the sides of the shaft, and remove any loose stones; and, if anything is faulty or unsafe, stop sinking until it is made secure.

119. The leading Sinker shall see that the Kettles are not more than level filled; that the stones are properly packed; that no stones or loose materials are sticking to the bottom; that all tools, gear, and timber are properly secured; and that the Kettles or Barrels are put in a line with the rope and properly steadied before being sent up.

120. The leading Sinker shall allow no shots to be fired except under his supervision, nor until the Kettle is conveniently placed and a signal has been given from the surface that the Engineman is in perfect readiness to draw away; and, after a missed shot, no one shall enter the Pit until thirty minutes shall have elapsed.

121. Explosives shall not be kept in or taken, or sent into the Pit until immediately before they are required for use.

122. In any Pit, in the course of sinking or re-sinking, in which inflammable gas shall have been found in dangerous quantities within twenty-four hours immediately preceding a cessation of work, whether caused by the withdrawal of the workers for shot-firing purposes or other causes, the leading Sinker shall, before allowing the rest of the men to enter, and accompanied by one other person, descend and examine the Pit with a Safety Lamp, and report the result of his examination to the other sinkers.

123. Not more than four men shall ascend or descend on a Kettle.

124. The Ordinary Special Rules shall also apply to Pits or Mines in course of sinking or re-sinking, in so far as necessary and reasonably practicable, but only in so far as not inconsistent with the immediately preceding Rules.

CODE OF SIGNALS.

From Bottom to Surface.

Ring *Once*, for the ascent of the Cage, whether loaded or empty.
„ *Once*, when the Cage is in motion to stop.
„ *Twice*, to make the Cage descend.
„ *Thrice*, in rapid succession, to signify that men are about to ascend.

From Surface to Bottom.

Ring *Once*, to signify that all is ready.
„ *Twice*, to signify that the cage should not ascend.
„ *Thrice*, in rapid succession, to signify that the Cage should ascend empty.

Name of the Mine, _____

Name of the Owner, _____

Name of the Manager, _____

Name of Inspector, _____

Address, _____

N.B.—All persons employed in the Mine, in whatever capacity, are specially requested to peruse the whole of the Rules, under whatever head, so as to make themselves acquainted with the terms thereof.

The Secretary of State has objected to the Special Rules to the extent undernoted; and his proposed modifications may be referred to arbitration, as provided for in the Act.

Rule 23, line 3, omit "ropes" and "chains."

Rule 38 to be transferred so as to follow Rule 40.

Rule 44. Prefix "where the timbering of the working place "is done by the workmen employed therein."

Rules 73, 74, and and 75 to be omitted.

Rule 79 after "timber" add "Drawers, while drawing down "roads having such an inclination that the hutches run by gravi-"tation, shall not go in front of the hutches."

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW,

31st May, 1888.

JOHN M. RONALDSON, Esq., President, in the Chair.

Fully 20 members were present.

The minutes of the Annual Meeting were read by the Secretary and confirmed.

The following gentlemen, who had been duly nominated, were elected by ballot as Ordinary Members :—

JAMES SALMOND, Barncluith Colliery, Hamilton.
JAMES M. STRAIN, Rigg Colliery, Airdrie.
JOHN GILCHRIST, 2 Old Terrace, Muirkirk.
JOHN BROWN, Midhouse Row, Muirkirk.
WALTER DRINNAN, Shotts Iron Works, Shotts.
JOHN THOMSON, Foulford Colliery, Cowdenbeath.

The following discussion then took place :—

DISCUSSION OF MR BARROWMAN'S PAPER ON "SCOTCH MINING LEGISLATION."

The PRESIDENT, in inviting discussion, said they had a large subject before them.

Mr ROBERT WADDELL did not think there was much room for discussion. The paper was very much a history of facts, but a very valuable history, and one there must have been a good deal of labour in getting up.

Mr BARROWMAN said probably the members had barely got justice as regards the discussion, seeing it was only two days since the Transactions were put into their hands. He might say that the reason of the delay was that he was anxious to get in as an appendix the special rules that had been proposed by a committee of the Coalmasters' Association. It was less than a week since he got that permission, and that was the reason why the paper was so long in being sent to the members. He might add that he had got permission to print the rules on the understanding that they should not be discussed.

It was agreed that the discussion should be adjourned, seeing the paper had been for so short a time in the members' hands.

The following paper on Stauss's Cage-Easing Apparatus was then read by Mr F. J. Rowan:—

STAUSS'S CAGE-EASING APPARATUS.

By Mr Fred. J. Rowan.

Although attempts have been made to do without appliances for preventing movement of cages at the pit-head, yet the risk which attends any sudden movement there while cages are being emptied or filled is too great to induce many to work without safety arrangements of some kind, the more especially as they do not involve much cost.

The fact, however, that such attempts have been made is to some extent a proof that the "wings," or "shutters," or other appliances in use are not entirely satisfactory, and on this account more interest may attach to the description of an apparatus which has found much favour in German mining districts.

I am indebted for the loan of the model and illustrations and for the following particulars to Henry Simon, Esq., C.E., of Manchester, who has introduced this invention of Herr Stauss's into Britain.

The great feature of this apparatus is the mechanical device which is employed to hold the cage firmly and securely when it has arrived at the landing floor, and to release it again for descent into the shaft without the necessity of the preliminary lift of a foot or two which is required to clear "shutters" or "wings," and which gives an undesirable sudden jerk or strain to the paid-out rope, besides requiring time and steam for this operation.

Figs. 1 to 4, Plate I., illustrate this appliance, and Plates II. and III. show plan and horizontal section of the arrangement at the pithead where it is used.

The casting *a* carries the loose shaft *l*, the hand lever *h* attached to same, the lever *k*, the shaft *d*, which carries both the bell cranks *ee* and also the pin *b*, upon which these are fixed. On the latter also the one-armed moveable catch *c* works, and it slides on the inclined plane *x* of the frame *a*; further, the crank *f* works on *b*, and this forms, together with the lever *k*, a knee-crank connected with the bolt *i*.

The cage-easer works in the following manner:—When the cage is to be held fixed or prevented descending, it rests upon

the surface y of the catches or tappets c; these latter rest upon the part x and against the pin b, and are thus held fast in both vertical and horizontal directions. The holding fast in the vertical direction is accomplished by the bell-crank e, which presses against the shaft d; whilst horizontal movement is prevented by the crank f, which in its turn presses against the shaft l through the bolt i of the lever k. In this manner the resting of the cage is ensured, and turning and displacement are impossible. The weight of the hand lever h presses the lever k when in this position down against the block m which is fixed to the casting a, so that a movement to any side is a perfect impossibility. When k is brought into the position shown in Fig. 4, and dotted in Fig. 1, viz., is moved through 60°, i is brought to position i', and b to b', by which the catches are drawn away from under the cage and also lowered at the same time, so that the cage can descend into the pit.

When the cage has again arrived at the pit-mouth, the hand-lever h is pushed back into its first position, the catch e projects, and the cage again rests on it.

Through the motion of the catch c about the pin b, it further results that, should the cage-easer have been left in its closed position, it is not possible for the cage to catch it in ascending. In this case, the cage would push the tappets c up before it, into the position shown dotted in Fig. 1, and when the cage has passed these fall into their right position by their own weight.

The friction which occurs between the faces x and y, and in the joints b and d is easily overcome by the hand-lever h, as the weight of the cage itself does the chief work, because it tends to push the tappets e back against the horizontal face x, which have an inclination of 9°. Let the weight of the cage and load be say 5 tons = about 5000 kg., and for the sake of simplicity take only one tappet in the following calculation, then at the commencement of the motion the pressure of c on x will be—

$$x = \frac{5000 \times 60}{155} + 5000 = 6936 \text{ kg., or 6 tons } 13\tfrac{3}{8} \text{ cwts.};$$

$$\text{on } b = \frac{5000 \times 60}{155} = 1936 \text{ kg., or 1 ton } 18\tfrac{3}{8} \text{ cwts.};$$

and on d = 1936 kg., or 1 ton $18\frac{3}{8}$ cwts.

With an angle of resistance (steel on steel) of 6°, the force

P, which tends to move c into a horizontal direction, is $P = 6936 \tan (9° - 6°) = 360$ kg., or $\times$ 7 cwts. The friction on the face of y and in the pins b and d acts against these forces with a co-efficient of $0.1 = \frac{2 \times 19.5 \times 30}{85} + 5000 \times 0.1 = 637$ kg., or 12.5 cwts.,—that is to say, it must overcome a pull of $637 - 360 = 277$ kg. in order to throw the apparatus out of gear. The proportion of the levers h to k is 14 to 1; therefore, if a force of say 20 kg. is applied to the lever, the force at i will be $20 \times 14 = 280$ kg. It is, therefore possible with the simple lever, and without the help of the knee-crank $k f$, to throw the apparatus out of gear. The knee-crank multiplies the strain, and, according to the law of forces, we can, with 20 kg. at the lever and with 5° inclination of the crank k, exert at b a power of 1560 kg.; with 10° inclination, 815 kg.; with 15° inclination, 660 kg., and so on. In other words, the power which we must exert at the crank h, in order to throw the apparatus out of gear with 5000 kg. load, is far below 20 kg. The friction in the bearings of the loose shaft l and in the knee-crank has been neglected in this calculation as unimportant.

Further, if the bell-cranks ee, turning on b round d, leave the vertical position, the pressure of the load of the cage tends to pull back the catch c towards the top and side, and to turn about d—that is, to overcome the friction and to support the force which works in i. The farther the catch is drawn out of gear, the greater grows the power, until, after passing a certain position, it would be suddenly thrown out of gear. Although this sudden action cannot be very detrimental, because the lever h has not very much play, yet it is better to avoid it, and this can be done by not giving the plane x too great an inclination. Practical experience prescribes an angle of 9°.

The application of this cage-easing apparatus, as compared with other arrangements, has effected much saving of time and steam, and also of the ropes and engine, because it is unnecessary to lift up the cage previous to descent. According to the dexterity of the engine-driver and the onsetter, and depending on the construction of the engine, a saving of 4 to 6 seconds at each descent, or more according to the size of the cages, can be realised. The corresponding saving of steam amounts to at least two cylinders full.

The use of other cage-easers hitherto applied (except the hydraulic caps, which however are not altogether reliable in action) necessitates that the engine be capable of lifting up the cage with empty hutches; therefore lifting, with an effective load of 2.5 tons, at least 5 tons—namely, double the amount of the usual load. In applying this new cage-easing apparatus, the engine may be made, in case of new installations, just sufficient to lift up the cage or the effective load at a certain velocity. This is a great advantage as soon as the weights of the ropes are equalised, because the fittings can be smaller and a saving in first cost may be thus effected. This arrangement is also found in practice to act more safely in case of inattention on the part of the engineman, because it is apparent that the engine-power would not be sufficient to lift up the cage very much above the bank.

For example, in one of the first applications of Stauss's Easer, at a pit near Fabrze, which has been at work since April, 1884, the cylinder of the engine is 19 inches diameter, the piston has 40 ins. stroke, and the winding drum is 12′ 9″ in diameter. The steam is cut off at $\frac{3}{8}$ stroke, and the boiler pressure is 60 lbs. per square inch. With an effective load of $2\frac{1}{2}$ tons, and a velocity of about 20 feet per second, this apparatus acts with certainty, and gives excellent results.

A very great saving is effected in the ropes and engines, because the short jerks which injure them in lifting before letting down the cages are done away with. In the application of this cage-easer the ropes must of course be tightened in order that the cages after release do not drop, even though at the utmost they could only drop to the extent that the rope stretches.

The shortening of the ropes is easily accomplished by the tightening apparatus of E. Freudenberg of Lipine, Upp. Silesia. This is, however, only necessary during the first few days, and with new ropes.

This apparatus has been used to a very great extent in the districts of Upper Silesia, where its usefulness has been fully proved. It is hoped it will be found worthy of introduction in other localities.

The following table gives the names of several collieries where

this apparatus is in successful operation, and some particulars of the work and dates of installation:—

Name of Firm Employing the Stauss Cage Easer.	Name of Pit where at Work.	Number Employed.	Load on the Cage.	At Work since, and Remarks.
		Pairs.	Tons.	
I. Silesian Zinc Mining Co., Lipine,	1. Joseph Pit, Westfeld, - - -	2	10	No. 1883.
	2. Pit III., Ostfeld, -	2	5	Au. 1884.
	3. Carsten-Centrum Pit, near Beuthen,	2	10	Oc. 1885.
II. Donnersmarkhütte, near Fabrze, - -	4. Julia Pit, - -	2	10	Fe. 1884.
	5. Concordia Mine, }	2	10	
	6. Near Fabrze, - }	6	2	"
III. United Königslaurahütte, -	7. Richter Pit, - -	2	5	Au. 1884.
	8. Countess Laura Pit,	4	2·5	Au. 1887.
IV. Royal Berg Inspection, Fabrze, Queen Louisa, -	9. Poremba, Pit II., -	2	10	Jy. 1885.
	10. " " -	2	2	"
V. Emma Mine, near Rybnik, U S., -	11. Emma Pit, near Loslau, - -	2	5	"
VI. Henckel Hugo Donnersmark, -	12. Silesian Mine, near Konigshütte, -	4	10	"
VII. Georg v. Giesche's Erben, - -	13. Grundmann Pit, -	2	5	Mh. 1885.

DISCUSSION.

The PRESIDENT asked if there was a steel plate on the bottom where the cage rested, because there was a certain amount of friction when it was withdrawn.

Mr ROWAN said he presumed that part was made of steel, although it was not specially mentioned. On account of the motion of the catches when being released, however, there was very little rubbing.

The discussion was adjourned.

The following report of the Committee on Experiments with Roburite was then read by the Secretary:—

COMMITTEE'S REPORT ON EXPERIMENTS WITH ROBURITE.

A DESCRIPTION of the chemical composition of Roburite is given at page 6 in the notes appended to this volume.

The Roburite Explosives Company (Limited), by whom it is manufactured, state that this explosive is especially valuable on account of the great safety with which it may be handled; that neither friction, percussion, nor heat will cause it to explode, a specially strong detonator being required. As a blasting agent for coal mines it is stated to be practically flameless; gives off no noxious fumes; and does not pulverize the coal. The initial flame of the explosive is said to be quenched by the gases evolved in the combustion of the explosive. It is further claimed for roburite that its power is as four to one of blasting powder, weight for weight; that it does not freeze; and that while it loses its power when damp, it can be restored by drying.

With the view of ascertaining if this would be a fit explosive for use in fiery and dusty mines, the Committee, by arrangement with the manufacturers, had some experiments made on 28th February last, at Bent Colliery, Hamilton; the charging and firing of the shots being done by an operator of the Company under the direction of Mr Wither, their general manager.

The experiments took place in the Main coal seam, at a place that is worked long-wall, and has the following section :—

Blaes "Brushing."	
Free Coal, - - - -	3ft. 0in.
Coarse Parrot Coal, - -	0ft. 5in.
Free Coal, - - - -	0ft. 9in.
Pavement.	

The roburite, which is of a yellowish colour and plastic, was made up in cartridges 5 inches long, nearly 1½ inches in diameter, and weighing 3¾ ounces. The quantity of the explosive used in each shot was taken at a fourth of the estimated quantity of gunpowder required to do the work. Whole cartridges, or portions of cartridges, according to the quantity necessary, were inserted in the shot-hole, and the detonator thrust into the centre of the cartridge at the outer end, and, after being stemmed, the shot was fired by an electric exploder.

Nine shots in all were fired, and the following are the particulars:—

Experiment No. 1.—A rib-side shot in the coal:—

Depth of holing (at bottom of seam),	4ft. 3ins.
Height of holing at front,	1ft. 6ins.
Distance of hole from fast side,	1ft. 2ins.
Distance of hole from roof,	7ins.
Depth of hole,	3ft. 6ins.
Diameter of hole,	1½ins.
Weight of cartridge,	1¾oz.

The hole was not straight, and the cartridge could not get to within one foot of the back of the hole. It was then stemmed to within 10 inches of the mouth, and fired. The coal was brought down to within an inch of the back of the hole, but smashed, showing that for the work required the charge was too heavy. The fumes resulting were slight, and no flame was visible.

Experiment No. 2.—A shot in the longwall face, and no shearing on either side:—

Depth of holing,	4ft. 6ins.
Height of holing at front,	1ft. 6ins.
Distance of hole from roof,	4ins.
Depth of hole,	3ft. 6ins.
Diameter of hole,	1½ins.
Weight of cartridge,	1¾oz.

The hole was stemmed to within 22 inches of the mouth, and fired. It proved a blown-out shot, and no flame was visible.

Experiment No. 3.—A brushing shot in centre of road:—

Width of road,	9ft.
Thickness of brushing,	3ft.
Distance of mouth of hole from roof,	7ins.
Depth of hole,	3ft. 3ins.
Diameter of hole,	1½ins.
Weight of cartridge,	About 15 oz.

The shot was stemmed and fired, and it was found that the brushing had been taken down about a foot beyond the bottom of the hole. The spectators could not safely stand in view of this hole when it was fired, and did not therefore see it at the time of firing. The result shown in the condition of the blasted material was satisfactory.

Experiment No. 4.—A brushing shot in centre of road :—

Width of road,	10ft. 6ins.
Thickness of brushing,	3ft.
Distance of mouth of hole from roof,	6ins.
Depth of hole,	4ft. 1in.
Diameter of hole,	1½ins.
Weight of cartridge,	15oz.

This shot brought down the rock 9 inches beyond the end of the hole. The state of the rubbish showed that the blast had been too strong, and the quantity of fumes was considerable. A view was had of this hole at the moment of blasting, and no flame was seen.

Experiment No. 5.—A rib-side shot in the coal, the face standing at right angles to the rib-side, and the hole parallel to it :—

Depth of holing,	6ft.
Height of holing at front,	2ft. 3ins.
Distance of hole from fast side,	1ft.
Distance of hole from roof,	8ins.
Depth of hole,	4ft. 1in.
Diameter of hole,	1½ins.
Weight of cartridge,	1¾oz.

The full height of the seam in this case was 4ft. 8ins. After being stemmed, the hole was fired. No coal was brought down, but it was shaken. No flame was seen.

Experiment No. 6.—A brushing shot in the centre of a road :—

Width of road,	10ft. 6ins.
Thickness of brushing,	2ft. 6ins.
Distance of mouth of hole from roof,	9ins.
Depth of hole,	3ft. 7ins.
Diameter of hole,	1½ins.
Weight of cartridge,	9oz.

About a third of the rock was brought down, and the remainder shattered. No flame was seen. The fumes were considerable.

It will be seen that, in several of these experiments, the quantity of the explosive was not quite balanced to the work it had to do ; but it is to be borne in mind that no preliminary trials had been made to get practical experience of the most suitable quantity for the coal and stone to be blasted. The effect of the several shots appeared to be very similar to what would have resulted from the use of gunpowder.

The remaining three experiments were made in a stone mine, and in one hole bored vertically in the pavement specially prepared to produce a blown-out shot.

Experiment No. 7 :—

Depth of hole, - - - - - - - -	3ft.
Diameter of hole, - - - - - - - -	1½ins.
Weight of cartridge, - - - - - - -	3¾oz.

Six inches of stemming were put in, and the shot fired. A light was seen, but the observers could not say distinctly whether it was the reflection of a flash within the hole or a flame outside. From their point of view, about 40ft. distant, it resembled a faint shower of sparks.

Experiment No. 8.—The hole was stemmed again with 2ft. of stemming—the same size of cartridge being put in. Again a light was seen, but not quite so bright as in the last experiment.

Experiment No. 9.—With 2ft. 4ins. of stemming, and the same size of cartridge, the shot was fired, and a light was seen on this occasion also.

The Committee were satisfied that roburite is an effective and manageable explosive. As to its safety in a fiery atmosphere, the experience gained by these trials would not justify them in giving an opinion.

DISCUSSION.

The PRESIDENT asked if the fumes from the roburite seemed to be offensive in any way.

Mr ROWAN said there was a small quantity of hydrochloric acid given off by the decomposition of the roburite, and he specially tried, as far as he could, to inhale the fumes to see the effect of them, and he could not discover any bad effects. The bulk of the gases produced were carbonic acid and steam. There was nitrogen also, but of course it was impossible to say without analysis what was the composition of the gases containing nitrogen or chlorine when the powder was incompletely burned. That could only be ascertained by practical tests, but, as far as one could judge from the fumes given off, they were not at all disagreeable.

Mr ROBERT WADDELL asked if roburite could be as safely handled as dynamite or gelatine.

The SECRETARY said they were assured by the manufacturer that it was perfectly safe to handle, and could not be exploded by friction or heat. It required a specially strong detonator.

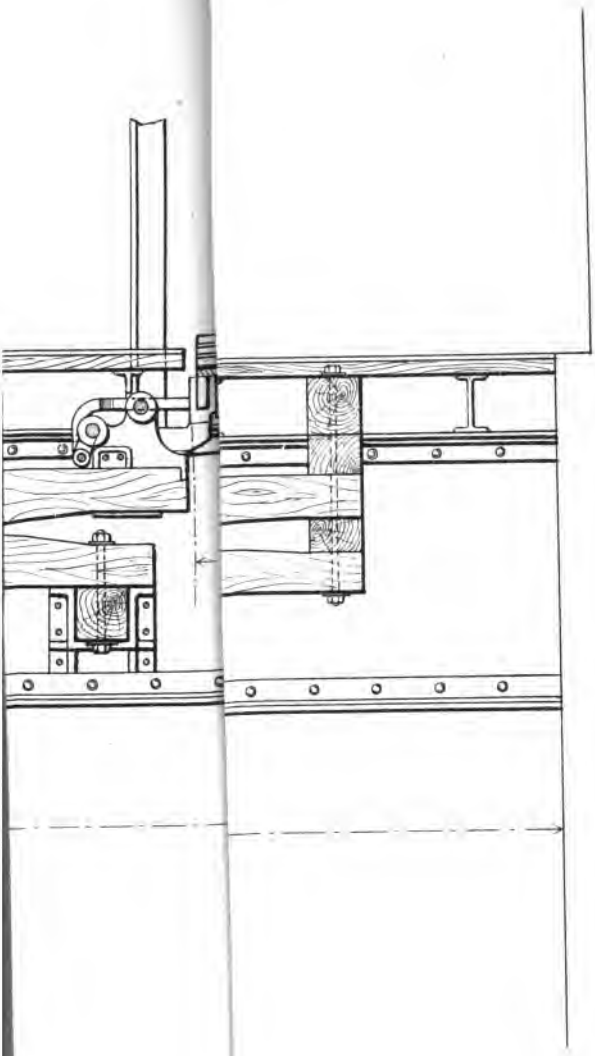
Mr WADDELL asked as to the price.

Mr ROWAN said, in conversation with the manager, he led them to understand that a scale of prices had been arranged to make it practically equal to the price of gunpowder. That was to say, if it was four times as powerful the price would be, weight for weight, four times as much. The members would find in the Transactions of the Midland Institute some very interesting experiments which had been made by mining engineers in England with this explosive before those experiments which had been mentioned at Bent. The question of flame produced was gone into in the most careful manner, and altogether the series of experiments was very interesting. It was rather too long to abstract for the Transactions. This, of course, was only one of a series of explosives that had been brought out.

The SECRETARY said they were arranging for a trial with another flameless explosive, but the necessary license had not been got from the Home Secretary.

Mr ROWAN said the authorities in this country were extremely slow to move in the case of new explosives.

The discussion was then adjourned.



THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

12th July, 1888.

JAMES SMART, Esq., Vice-President, in the Chair.

The minutes of the former General Meeting were read by the Secretary and confirmed.

The following gentlemen, who had been duly nominated, were elected by ballot as Ordinary Members :—

ROBERT YOUNG, Kinneil Iron Works, Bo'ness.
ARCHIBALD STARK, Blantyre Collieries, High Blantyre.
W. H. WILLIAMS, Shag Point Colliery, Shag Point, Otago.

The following discussions then took place :—

DISCUSSION OF MR. BARROWMAN'S PAPER ON "SCOTCH MINING LEGISLATION."

The CHAIRMAN said he had read this paper with very great interest. There was at the present time a great deal said about royalties and the coal belonging to the people. Throughout the paper he did not see that any of the Acts quoted conferred the right of possession to the coal. There were several cases of grants to members of certain families, and to the monks, but he supposed the monks held the land as well as the coal. He would like to ask Mr Barrowman if he could give any further information on the point.

Mr BARROWMAN said so far as he could make out, the Public Acts of the Parliaments of Scotland were silent as to coal. All the Acts referring to minerals had regard, not to coal, but to the precious metals.

The CHAIRMAN asked if in such cases as the grant mentioned to the House of Hamilton, coal was not included?

Mr BARROWMAN—The grants of mines and minerals refer to precious metals. Wherever coal is included the words "coal heughs" are used. A good deal was said in some quarters as to the right of the Crown and the people to minerals; but, as he had said, minerals in the old Scotch Acts did not include coal, so that those who claimed for the people certain rights to coal must go elsewhere than the Acts of the Scotch Parliament for their authority. The Act of 1592 had been stated to be the regulating statute. There was not a word in it about coal; and he was satisfied from the Act itself and collateral evidence that coal was not intended to be included in its provisions. As to minerals, there was reserved to the Crown by that Act a tenth part of gold and silver only.

The CHAIRMAN closed the discussion, and on his motion a hearty vote of thanks was awarded to Mr Barrowman for his valuable paper.

DISCUSSION OF MR ROWAN'S PAPER ON STAUSS'S CAGE-EASING APPARATUS.

Mr JAMES GILCHRIST asked what would happen on the lowering of the cage from the rests if there were 12 or 18 inches of slack rope. Would the sudden jerk on the rope not be apt to snap it? In that case, they would require to have the chains perfectly taut, and they might still require to have a brake to hold the cage in position. Possibly Mr Rowan had foreseen this and might be able to explain it.

Mr ROWAN said that not having worked this apparatus, of course he was only able to give his own ideas, and what occurred to him was that if there were so much slack chain as was mentioned in the case of the cage at the pit bank, he should like to know where the other cage would be. It would be so far up the shaft that it would be impossible to load it at the pit bottom.

Mr GILCHRIST—The chains are never so nicely adjusted but that there is a little slack.

Mr ROWAN—12 or 18 inches?

Mr GILCHRIST—In some cases there might be more. It might be bad practice, still it was not uncommon.

Mr ROWAN said there was no doubt if there was so much slack rope allowed the cage would drop after it got clear of the easer. In the case of the present shuts, they heaved up and did not get that jerk, but they got one on the cage below, because they paid out the slack rope on it; and that was the point that was sought to be obviated by this apparatus. He pointed out that at the end of his paper reference was made to an apparatus for tightening the chains or ropes, which was in use for that purpose in over a hundred collieries on the Continent in conjunction with Stauss's cage-easer.

Mr GILCHRIST said in that case there might be no slack rope or less slack rope than with the system they had in this country. The ropes in that case were perfectly tight, which might be the reason why this new system was introduced.

Mr ROWAN asked if there was anything to prevent the ropes being made just the proper length. He did not see the object of all this slack rope.

Mr GILCHRIST said they could not send a man every day to pick out a link or two, and they could not similarly be taking their rope in on the drum, and that was the only way in which they could shorten the rope. After a new rope had been put on, it lengthened considerably, and sometimes it stretched so far that they had to take it in on the drum. In other cases, they had an extra long chain, and gradually reduced it. But, as he had said, they could not do that every day.

The CHAIRMAN said he was inclined to be a little of Mr Gilchrist's opinion. He could not see that there would be much saving to the rope.

Mr ARNOTT—There would be a saving of time.

Mr ROWAN, in reply, said he thought the objection to the use of the appliance was not a very serious one, because it only meant that the ropes should be adjusted a little more carefully than had been the practice hitherto. As to the question of the effect of a jerk, at present, by the system of shuts, it was given to the rope that was paid out—and they would not forget that it was given on the loaded cage—whereas the drop in the case they supposed would be on the empty cage, and therefore a good deal less severe on the ropes than at present.

Mr GILCHRIST suggested that Mr Rowan might ascertain where the tightening system was in use—whether it was in regard to ropes used in the ordinary way, or on Keope's system.

Mr ROWAN believed it was in the ordinary system from the large number of applications of it. He did not think Keope's system was in such general use. He would be glad to make inquiry.

Mr HENRY ROWAN asked if the same thing could not be done without this system at all. Collieries in the neighbourhood worked without shuts, the scaffold where they put on the hutches being an inch or so above where the loaded ones were taken off, and the jerk was saved.

Mr ARNOTT—That system is in daily use at Clyde Collieries.

Mr ROBERT M'LAREN said there was scarcely such a thing in Fife as shuts, and the tubs there were from 4 cwt. to 5 cwt. empty, and gross 14 cwt. The cages were double, two abreast and sometimes double-decked.

Mr GILCHRIST said at Earnock, in connection with the hoist, the gross weight of the hutch was 36 cwt., and they had no shuts.

The CHAIRMAN moved a vote of thanks to Mr Rowan, which was heartily given.

DISCUSSION OF THE COMMITTEE'S REPORT ON EXPERIMENTS WITH ROBURITE.

Mr F. J. ROWAN said since last meeting he had noticed some particulars about the explosive called securite—one of those belonging to the Flameless Explosives Company—given in the late number of the Transactions of the Midland Institute. It seemed that Mr George Blake Walker, who carried out some very interesting experiments on roburite, which were abstracted in the last number of their Transactions, had the same difficulty in getting securite from the Flameless Explosives Coy. that this Committee had, but he had given in an addendum to his original paper on Hydro-carbon Explosives some interesting particulars about it—all that he had been able to gather. Securite was one of the so-called hydro-carbon explosives, to which class roburite and helhoffit also belong. Although Herr Schöneweg of Dudweiler claims securite as his invention, there is no doubt it is one of the explosives described by Sprengel in his pamphlet published in 1873. A good proof of this is that the German Patent Office refused Herr Schöneweg a patent for it, although he has obtained one in Britain. It is said that securite has also been patented by a Swede under the name of Bellite. Securite is said to consist of di-nitro-benzol mixed with saltpetre, and Herr Schöneweg's plan of preventing flame is said to be by the use of oxalic acid either in the cartridges or mixed with the explosive. This, besides being an expensive material, gives off poisonous carbonic oxide on explosion. The behaviour of securite in blasting, as to power and safety, is precisely similar to that of roburite, and is said to be better than that of carbonite and helhoffit. He had

been trying to get a copy of Sprengel's pamphlet, but as yet unsuccessfully. He thought if they could get a copy for the library it would be worth having.

Mr M'LAREN said it would have been desirable if in the experiments 3, 4, and 6, the distance from the brushing to the coal face had been given. It seemed that, in the case of 6, the distance had been short. It was quite well known in a long-wall working brushing was more easily brought down if it had stood for some time.

The SECRETARY said in no case was the brushing blasted down to the coal face.

Mr ARCHD. BLYTH said in the brushing in the Main coal they did not find it as Mr M'Laren had stated. When the brushing hung, it was always more difficult to bring down.

Mr JAMES HASTIE said in the most of his experience the brushing near the face was the easiest. If it stood for a time, the shot had not the same effect in blasting it off.

Mr M'LAREN—Could the committee give any idea as to how much brushing was on in each case?

The SECRETARY—There was no note taken, but I think I am safe in saying that in all cases there would be 8 or 10 or perhaps 12 feet of brushing still on.

The committee were thanked for their diligence, and continued for further experiments.

THE MINING INSTITUTE OF SCOTLAND.

SUMMER MEETING, 23rd AUGUST, 1888.

THE annual summer meeting, which included an excursion to Newbattle and Arniston Collieries, Midlothian, and dinner and a general meeting in Dalkeith, took place on 23rd August, 1888. Members from the West journeyed to Glasgow in time for the 8.45 express train to Edinburgh, and along with those from other districts, numbering in all about seventy, were conveyed by special train to Newbattle Colliery, which was reached about 11 o'clock. This colliery is on the property of, and worked by, the Marquis of Lothian. They were received by Mr John Morison, the general manager, who showed them round the works. For the convenience of the visitors, Mr Morison had provided a printed description of the special features of the colliery, and copies were distributed and were found very useful. A copy of the description will be found at page 146. A number of the party went underground to view the haulage engines, the double-rope system of endless rope haulage, and the dook pumping by compressed air worked on the compound system.

The members then left for Arniston Colliery, about a mile distant. This colliery, which is on the property of Mr Dundas of Arniston, is leased by the Arniston Coal Coy., Limited, and is under the management of Mr Robert Clark. Mr Clark received the visitors and conducted them over the works. A description of the special features of the colliery, kindly provided by Mr Clark, follows hereon at page 148.

At 2.30 the party left Arniston siding by special train to Eskbank, and walked from there to Dalkeith, and dined in the Cross Keys Hotel. In the absence of Mr J. M. Ronaldson, the president, Mr James S. Dixon, ex-president, occupied the chair; Mr Clark and Mr Morison being croupiers.

After dinner,

The CHAIRMAN announced a letter of apology from the President, regretting his inability to be present on account of illness, and wishing the members a pleasant and profitable day's outing. It was not usual, he said, at their summer meetings to have any toasts, loyal, patriotic, or otherwise, but before the business meeting took place he thought they could not do less than thank the gentlemen (Mr Morison and Mr Clark) who had entertained them that day. (Cheers.) He was sure they had had a profitable excursion. The collieries they had visited contained a great many appliances which were well worthy of the study of every member of the Institute, and he had no doubt they would make use of what they had seen. They had met with very great hospitality at both places, and they certainly had enjoyed themselves to the full. (Cheers.) He concluded by asking them to accord a hearty vote of thanks to the owners of Newbattle and Arniston Collieries, coupled with Mr Morison and Mr Clark. The Chairman's call was responded to with enthusiasm.

Mr CLARK responded. He said it had given him the greatest pleasure to see them all there that day. It was a new thing for the Mining Institute to visit that part of the country. They were trying their best, and he had no doubt from what they had seen that day they would admit that they were up as near as they could to the west country. (Cheers.) So far as they were concerned at Arniston, it was a plain-going concern; but as the Institute had come for a day's outing, if by what they had shewn them they had been able to please the members, it would please him very much. (Cheers.)

Mr MORISON also replied. He said he was very pleased indeed to have a party like the Mining Institute to come out and see what they had to shew them. Probably, there were things done there, in the same way as there were things done in the west,

which were strange, and which at some time or other might prove of use; and it was always interesting to an Institute like that not only to shew members what they had not seen, but what they were likely to see, and that to their cost probably, at some future time. (Cheers.) They had in the east a different condition of things from what was to be met with in the west and other parts of Scotland, inasmuch as they had very steep measures to contend with, and had to provide means and facilities for working those steep coals, which were not known in the West of Scotland; and he could only say to the members from the west who were there that the less they saw of steep workings the better. (Cheers.) They were delighted to have the honour of such a body coming to see them. They had all benefited by the members in the west throwing their collieries open to them, and he thought the very least they could do was to do the same in return. (Cheers.) And speaking on his own account—and he was sure Mr Clark shared the feeling—they were very proud indeed to have the members there and to show them what they had, however little that might be. (Cheers.)

Immediately after dinner there was held a

GENERAL MEETING.

JAMES S. DIXON, ex-President, in the Chair.

The minutes of the last general meeting were read by the Secretary and confirmed.

The following were elected by ballot as ordinary members:—

ROBERT MOORE, Pumpherston Mines, Uphall.
HENRY NISBET, Kinneil Colliery, Bo'ness.
JOHN WHITESIDE, Ballochmyle Colliery, Auchinleck.
ROBERT FISHER, Thorniehill, Crosshouse, Kilmarnock.
HUGH GRAHAM, Shotts Iron Works, Shotts.

Thereafter Mr JAMES HASTIE, Greenfield Colliery, Hamilton, was elected a vice-president in room of Mr David Anderson, resigned; and Mr WALLACE THORNEYCROFT, Merryton Colliery, Hamilton, a councillor, in succession to Mr Hastie.

DESCRIPTION OF NEWBATTLE COLLIERY.

Seams Worked.—Great Seam, Coronation Seam, Splint Seam, Parrot Seam.

Pits.—Engine Pit, 150 fathoms; Dickson's Pit, 110 fathoms.

Inclines.—Dalhousie Incline, 140 fathoms vertical depth below bottom of Engine Pit, making total depth 290 fathoms.

Method of Working.—All seams long wall. Main level, with lifts of 50 fathoms on the incline.

Method of Haulage.—Upon incline, endless ropes, and single ropes; upon level roads, compressed air engines, with engines at each end of plane; and with horses.

Pumping.—In pit, Bull engine, 60in. cylinder, 12ft. stroke, with working parts in pit 19in. diam. Dip pumps, compressed air, and ram pumps worked by steel rods, with engine at head of incline. Steam pipes down pit.

Incline of Seams.— 30 degrees.

Objects of Special Interest.—Pair of compound condensing air-compressing engines; high pressure steam cylinder, 18in.; low pressure steam cylinder, 36in.; boiler pressure, 100lbs. per square inch. Steam supplied by one Lancashire boiler, 28ft. by 7ft. 6in. Air cylinders, 28in. and 17½in., capable of compressing air up to 120lbs. per square inch.

Plant in connection comprises—three Tangye's special pumps—18″ × 9 × 36, 20⅔″ × 9 × 36, 24⅓″ × 9 × 36—with a total column of 110 fathoms.

These pumps are placed at a vertical distance, upon an incline of 27 fathoms, 36 fathoms, and 47 fathoms respectively. 4in. air pipes are led from the compressing engines to No. 1. No. 1 exhausts by a 6in. pipe, which is connected to No. 2; and No. 2 exhaust is connected to No. 3; the pumps thus working with a triple expansion upon the air. The usual air pressure employed, when the pumps are so working, is 90lbs. per square inch; and the pumps are run twelve double strokes per minute. It is intended to exhaust from No. 3 pump into receivers, and work the hauling engines, &c., from the back pressure upon No. 3, which will amount to 30lbs. per square inch; but this is not yet completed.

The water discharge-pipes from No. 3 are connected to the suction pipes of No. 2, the discharge-pipes of No. 2 to the suction of No. 1, and No. 1 delivers at the head of the incline. No. 3 pump is capable of pumping the entire column through the valves of Nos. 2 and 1 to the surface, and can do this with a working pressure of 60lbs. per square inch.

There is no trouble with freezing when the pumps are working triple; but a little trouble if No. 3 is working alone. With the compressing engines running at equal speeds, it is found that the pumps run about 5 strokes less when No. 3 pump is doing the work alone, than when the three pumps are working triple.

The other plant in connection is two pairs of 6 inch hauling

engines, one pair 9 inch incline engines, one pair 6 inch sinking engines, two 12 inch by 18 inch special pumps, one 16 inch by 18 inch rotary pump.

The hauling engines run on a level road, with a load of 40 tubs, at a speed of 4 to 6 miles an hour.

Endless Rope Incline.—This has already been described in a paper by Mr A. M. Grant, lately read before the Mining Institute of Scotland. (Trans., vol. ix. p. 211.)

The incline is at an angle of 30 degrees. Two 4 inch ropes are driven by a pair of 14 inch engines with V pulleys. The load on the incline is usually 20 full and 20 empty tubs, and the usual speed of delivery is 3 tubs per minute.

General Plant.—Pair of 24 inch winding engines, Engine Pit. Pair of 22 inch winding engines, Dickson's Pit. Guibal fan, 30 feet by 10 inches, with compound condensing engine. 30 inch beam engine, working Lingerwood incline. 30 inches by 5 feet, horizontal engine, working underground pumps. Pair of 14 inch hauling engines underground, &c., &c. Robinson's coal-washing machine.

DESCRIPTION OF ARNISTON COLLIERY.

Emily Pit is sunk 160 fathoms to the Parrot seam, and from there a dook 300 fathoms, arched with brick the whole length, and dipping 1 in 2½, is run in the coal seam. The coals are drawn by a pair of 22 inch cylinder engines (coupled) with a single plough steel rope, and drawing 800 hutches of coals in eight hours. It is drained by two double-acting hydraulic pumps with 6 inch rams, the motive power supplied being a feeder of water 70 fathoms up the shaft. The pumping engine on surface is a direct acting one of 80 inches diameter of cylinder and 12 feet stroke. There are 5 forcing sets of pumps in the shaft—3 with 16 inch rams, and 2 with 14 inch rams, the weight of pump rods, &c., being about 90 tons. The winding engines are 22 inch cylinder (coupled), and draw 2 hutches at a time placed alongside of each other on the cage.

Gore Pit is 116 fathoms deep, and fitted with coupled winding

engines, 26 inch cylinders, and drawing 4 hutches every run, the cages being of that size to hold this number on one deck. The haulage is by endless rope, driven by 14 inch cylinder engine on surface, the length of haulage being through a cross cut mine 280 fathoms, then 300 fathoms, dipping 1 in 7 in the Splint seam. The endless rope also drives two 5 inch force pumps to drain the 300 fathoms. There is also on surface an 18 inch cylinder engine, drawing coals from a dook 370 fathoms, dipping 1 in 8 in the Kailblades seam.

The whole colliery is ventilated by a 30 feet guibal fan, driven by a 22 inch cylinder engine, erected by Dick & Stevenson, Airdrie.

The annual output of the Colliery is 180,000 tons, worked from the following seams:—

Great Seam, ...	6	feet thick.
Splint Seam, ...	4½ feet to 5	„
Kailblades Seam, ...	4½ feet to 5	„
Parrot Seam, ...	2½	„

Brickwork.—In connection with Arniston Colliery, there is an extensive brickwork. The bricks are made in a semi-dry state and burned in a large Hoffman kiln.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW,

11th October, 1888.

JOHN M. RONALDSON, Esq., President, in the Chair.

The minutes of the last General Meeting were read by the Secretary, and confirmed.

The following gentlemen, who had been duly nominated, were elected by ballot as Ordinary Members :—

JAMES MOFFAT, Burghlee Colliery, Loanhead.
JOHN ROY, Castlecary Fireclay Works, Castlecary.
DAVID ARCHIBALD, Pentland Mines, Loanhead.
EVAN POWELL, Pentland Mines, Loanhead.
WM. HAMILTON, Pentland Mines, Loanhead.
WM. RODGER, Fergushill, Kilwinning.
JOHN CLARK, Arniston Colliery, Gorebridge.
WM. SPEIRS, Balgonie Colliery, Thornton.
WM. JOHNSTON, Coaltown of Wemyss, East Wemyss.
ROBERT GRANT, Uphall.
DAVID BEVERIDGE, Kirkness Colliery, Lochgelly.
DAVID ADAMS, Hill of Beath, Crossgates.
WM. STEVENSON, Drumshangie Colliery, Airdrie.
SAMUEL POTTS, Burnbank, Hamilton.
ROBERT SIMPSON, Auchter House, Newmains.
DANIEL BURNS, Westburn Colliery, Newton.

The following paper, on "Haulage by Self-Acting Endless Chains," was then read by Mr D. M. Mowat :—

HAULAGE BY SELF-ACTING ENDLESS CHAINS.

By Mr David M. Mowat.

It having been suggested to me that a description of the self-acting endless chain haulage at Dunsyston Colliery would be acceptable to the Institute, I thought it better to put together a few notes on self-acting endless chains generally, more especially as, in Scotland at least, the system has not been very largely taken advantage of.

I shall not, therefore, confine myself to a description of any particular example now in use, but will try to put before you the general arrangements required for a first-class self-acting incline, on the principle that, if we aim at perfection, we may arrive as near to it as possible. These arrangements would, of course, require some modification to suit the requirements of any particular incline to which the system might be applied.

Referring to Plate IV., Fig. 5 shews the arrangements at top and bottom of the incline. These consist, at the top, of a framework supporting a wheel (fig. 1) 4 feet in diameter fitted with a screw brake, and having a groove in which the chain may get a good bearing to prevent slipping; while at the bottom there is a similar wheel without the brake. Besides these large wheels, there are generally three 6in. bearing-up pulleys—one on the empty road at the top, and one on each road at the bottom of the incline. The incline is laid with a double road throughout its whole length, one road being always used as a full road, and the other as an empty road. The large wheels are connected together by an endless chain, to which the hutches are attached at regular intervals. The attachment consists of a vertical plate having a fork at its upper end, which allows the vertical link of the chain to enter, but prevents the horizontal link from slipping through. This chain plate may be either on the middle of the end, or on the side of the hutch according to circumstances. When the incline is very steep, and more especially if in the course of transit the loaded hutches require to be drawn uphill by an endless chain, the chain plate should be on the middle of the end (fig. 2), as in that case the tractive force is applied more directly in line with the resistance, and there is consequently less tendency to twist

the hutch off the road. To this arrangement, I think there is only one objection, which is that the hutch can only be loaded above the lip at each side, owing to the chain resting on the top of it. This objection can be partly overcome by raising the end of the hutch, as in fig. 2; and it is only an apparent objection when the inclination is as great as 1 in 4, as the hutch cannot then be filled much above the wood with any system of haulage, on account of the coals falling off.

When the incline is flat, the chain plate is better to be on the side of the hutch, but its position on the side should be fixed by local circumstances in each case. If, for instance, the incline dips in one direction only, so that the tendency of both full and empty hutches is to draw towards the pit-bottom throughout the entire length of the road, I think the proper place for the chain plate is on the start at the top end of the hutch (fig. 3), that is on the leading end of the empty hutch going uphill, and on the trailing end of the full hutch going downhill. If the chain plate is in this position, the chain drops down outside the low end of the hutch, and pressing against it keeps it from twisting, thus serving the same end as if two catches were used with the length of the hutch between them.

If, on the other hand, the road undulates, so that the chain may at one time be pulling and at another time holding back the hutch, a corner catch would not do so well, as, when the hutch came to be pushed by the corner, the leading end would separate from the chain, and a very small obstruction would suffice to put it off the road, besides which the tractive force would be very much increased owing to the twist on the hutch causing side friction between the wheels and the rails. In this case, therefore, the chain plate should be on the centre start (fig. 4), and if the chain is so tight that it might lie above the hutch instead of alongside it, the start should be extended up above the level of the hutch to a height of 4 or 5 inches, so that the chain may be certain to drop outside of it. This arrangement serves to keep the hutch square on the rails as well as if two catches were used with a distance between them equal to half the length of the hutch. On the incline at Dykehead Colliery, a section of which is shewn, the chain catch is on the end, as it was already in use for the

endless chain haulage to the surface when the self-acting incline was started. On all the other inclines of this kind worked by the Summerlee Iron Co. side catches on the centre start have been adopted, as the roads were either undulating, or the hutch required to be run on two separate inclines rising in opposite directions. We have not, therefore, tried the corner catch on any of our inclines, but I have made experiments with a single hutch, and found, as I expected, that it kept its parallelism to the rails more truly than when the catch was on the side. There has been, however, little or no difficulty owing to the twisting of the hutches, even on an inclination of 1 in $4\frac{1}{2}$; although, if the loaded hutches were going uphill, I hardly think it would be possible to work with a side catch, even if it were desirable, which I think it is not, for the reason already stated. The speed of the chain varies from one to three miles per hour, the best speed being about two miles per hour, although this may be increased with advantage to three miles when the output is very large, and the chain is not strong enough to allow of the hutches being placed closer together. The distance between the hutches varies from 10 to 25 yards, according to circumstances. If the road is very flat, they might require to be placed as close together as 10 yards to get sufficient motive power, while, if the incline is steep, 25 or 30 yards apart will give ample power. When the distance is greater than 25 yards, however, the chain is liable to trail on the pavement between the hutches, thus causing great tear and wear; so that, if possible, the distance should be shortened that the chain may never touch the ground except, perhaps, near the lower wheel, where it can hardly be avoided, and where beech planks should be laid to keep it off the pavement. The distance between the hutches is regulated by a small bell, which is placed on the incline at the prescribed distance from the hanging-on place, and which is rung by the last hung-on hutch striking it. The boy at the bottom puts on an empty hutch for every full one that comes off, thus keeping the number on both sides as nearly as possible uniform.

If the speed of the chain be taken as two miles per hour, and the distance between the hutches as 15 yards, the total number of hutches run off per hour, if the chain goes constant, would be

$\frac{2 \times 1760}{15} = 234\frac{2}{3}$ hutches per hour; or, if the hutches hold 10 cwts. each, 117 tons per hour. These figures show clearly that a very large output can be drawn, regardless of the length of the incline, without increasing the speed beyond a creeping pace.

When a change of gradient takes place, so as to form a hollow, as in the Dykehead incline, the road must be raised in the hollow and the inclination changed gradually, so as to prevent the chain from being lifted out of the catch. In short, the road must be made to follow the natural curve of the chain. When a chain is suspended between two points of support, it forms a catenary curve, but if it is drawn nearly straight between the supports, it may be taken as a parabola, whose axis is vertical, without sensible error. It order to find the parabola which the chain will assume, it is necessary to take into account the tension of the chain at the origin or lowest point of the curve, the weight of the chain, and the distance between the hutches, all of which are known, or can easily be found.

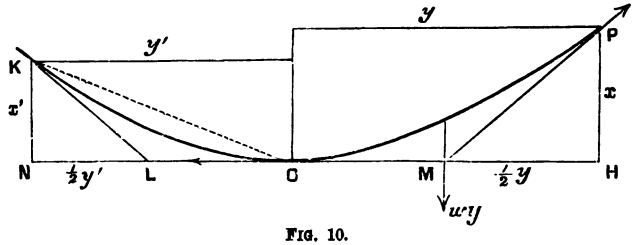


FIG. 10.

In Fig. 10 let T = tension at O in lbs.

w = weight of chain per foot in lbs.

OH = y = ½ span between supports in ft.

x = depression in feet.

wy = approximate weight of chain OP, when OP is nearly straight and level.

Then to find the depression x in the chain between the two hutches.

$$\frac{x}{\frac{1}{2}y} = \frac{wy}{T}$$

$$(1) \qquad x = \frac{wy^2}{2\,T}$$

and the equation to a parabola, when y and q are the co-ordinates and 4 A the ratio between x and y^2, is

$$y^2 = 4\,A\,x, \quad \text{but from (1)}$$

$$y^2 = \frac{2\,T}{w}x$$

$$\therefore 4\,A = \frac{2\,T}{w}$$

The curve is, therefore, a parabola, the equation to which is

$$Y^2 = \frac{2\,T}{w}x$$

Again, if it is desired to find the distance from the origin O of the parabola to the tangent K, where the curve will join a straight line KL, let the inclination of the line be expressed as the tangent of the angle KLN, that is, the vertical height divided by the horizontal distance—*e.g.*, 1 in 5 = ·20, 1 in 3 = ·$\dot{3}$.

$$\text{Then } \tan KON = \frac{\tan KLN}{2}$$

$$\frac{x^1}{y_1} = \frac{\tan KLN}{2}$$

$$\text{but } x_1 = \frac{y_1{}^2}{4\,A}$$

$$\text{therefore } y_1 = \frac{4\,A \times \tan KLN}{2}$$

$$\text{and } 4\,A = \frac{2\,T}{w} \quad (2)$$

$$\therefore ON = y_1 = \frac{T \times \tan KLN}{w} \quad (3)$$

Again to find the tension, in another place referred to as carrying tension, which must be applied in order that the chain may not trail on the ground.

$$x = \frac{wy^2}{2\,T} \quad (1)$$

$$\therefore T = \frac{wy^2}{2\,x} \quad (4)$$

Of course, x must be a less distance than the height of the point of support on the hutch above the ground.

For an output of 700 hutches per day, the following oncost would be required to keep the chain going, viz. :—One man at the top hanging on loaded hutches ; one boy at the top attending to the brake ; one boy at the bottom hanging on empty hutches, while the expense of upkeep of the incline would not be nearly so great as in an ordinary incline worked by a rope, owing to the speed being so low. To reduce the cost of attendance as much as possible, the inclinations should be arranged as in Fig. 5, so that the empty hutches arriving at the top will detach themselves and run forward into the lye for further transit by horses or drawers ; while the full hutches will detach themselves at the bottom end and run forward to the pitbottomer, or into a lye if the foot of the incline is not near the pitbottom. When the output is small, so as to allow of the chain going at a slow speed, the brakesman may be dispensed with, the bencher being able to hang on and look after the brake as well.

The flattest inclination at which an incline of this kind will self-act depends on the comparative weights of full and empty hutches, on the weight of the chain, and on the friction of hutches and chain wheels. As the chain should not touch the ground there is no friction due to it, except that at the chain wheels, and the extra friction which its weight causes on the hutch wheels.

If W denote weight of full hutches and chain on full side.
„ w „ „ empty „ „ empty side.
„ F „ friction of hutches, chain, and wheels on full side.
„ f „ „ „ „ empty side.
„ I „ tangent of angle of inclination, or inclination expressed as a fraction—*i.e.*, for 1 in 60—$I = \frac{1}{60}$

Then before the incline will self-act

$$(W \times I) - F \text{ must be greater than } (w \times I) + f$$

$$(W - w)\, I > F + f$$

$$I > \frac{F + f}{W - w}$$

The inclination found from the above formula would be that on

which the surplus power of the full side would just balance all the resistances, so that the incline would require to be steeper than this in order that it might self-act.

The friction would require to be assumed or found by experiment, while the proper size of chain may be found from the formula.

$$D = 3\sqrt{\text{Breaking strain in tons}}\text{; or}$$

$$D = 3\sqrt{\text{Working load} \times S}$$

D being the diameter of chain in sixteenths of an inch; and S being the factor of safety, which should be at least 5.

The working load on the chain is the greatest tension T, which is

$$T = (W \times I) - F + \text{Carrying tension.}$$

The chain should not be short-linked, as the chain-plate becomes fixed between the links of a short-linked chain and tends to prevent the hutches from detaching automatically.

In an ordinary self-acting incline the road must be more or less uniform in gradient, for if steeper in some parts than in others the train must be run over the steep portion with great velocity in order that it may acquire sufficient momentum to carry it through the flatter portion; while in a great many cases it is impossible to work an incline by trains at all if the flat portion of the road happens to be at the top and the steep portion at the bottom, as a start cannot be obtained.

In working with a self-acting endless chain, if the average inclination of the road is not less than I, as found from the formula, the incline will work no matter how undulating it is, provided the average inclination is calculated from the total length of the road and not from the horizontal distance on the section. The surplus power on a steep mine may be utilized for the purpose of drawing from a dook or level, not necessarily in the same straight line, by fitting the top wheel with a long shaft and putting on it a second driving wheel, or clip pulley, or rope drum provided with a clutch, as in Fig. 9. In the same way water may be pumped, or almost any description of work done, if the power be sufficient.

Figs. 6, 7, and 8 on Plate IV. shew three inclines on this system, and belonging to the Summerlee Iron Co. That shewn on Fig. 6

is at Dykehead Colliery, and is used for drawing the Ell coal down a mine to the Main coal and uphill in the Main coal to the engine haulage terminus. The gradients, commencing at the top, are—

12 fathoms,	-	-	level.
78 „	-	-	1 in $6\frac{3}{4}$ downhill.
98 „	-	-	1 in 588 uphill.

Or an average gradient of 1 in $16\frac{1}{2}$. There is a curve introduced at the change from the steep portion to the flat portion to keep the chain from lifting. The road is laid with edge rails, and the chain-plate, as already stated, is on the end of the hutch. This incline has been working for seven years, and the chain was an old $\frac{9}{16}''$ chain worn to about $\frac{1}{2}''$. The distance between the hutches is 25 yards.

The incline shewn on Fig. 7 is at Dunsyston Colliery, and has taken the place of an ordinary self-acting incline, which did not run well owing to the gradients at top and bottom being so unequal. The gradients, commencing at the top, are—

84 fathoms,	-	-	1 in 9 downhill.
86 „	-	-	1 in 18 „

or an average gradient of 1 in 12. The road is laid with common tram rails, and the chain-plate is on the centre of the side of the hutch. The chain is a half-inch one, and the distance between the hutches is 15 yards.

Fig. 8 is a section of an incline in Braidhurst Colliery. This road is very undulating, the gradients, commencing at the top, being—

27 fathoms,	-	-	1 in $10\frac{3}{4}$ downhill.
23 „	-	-	1 in 22 „
23 „	-	-	1 in $10\frac{1}{2}$ „
29 „	-	-	1 in 16 „
42 „	-	-	1 in 141 „

Or an average gradient of 1 in 19. The road is laid with edge rails, and the chain-plate is on the centre of the side of the hutch. The chain is an old half-inch one, and the distance between the hutches is 10 yards.

The advantages which a self-acting endless chain possesses over an ordinary incline may be summed up shortly, as follows :—

1st.—Small cost of upkeep of rolling stock, owing to slow speed causing few breakages; when a hutch goes off the road the chain stops.

2nd.—Regularity of delivery. The hutches arrive at the pit-bottom in such a manner that only very short lyes are required, and, consequently, the travel of the bottomers is diminished.

3rd.—When the output exceeds 100 tons a day, and probably before it, it can be worked much cheaper than an ordinary self-acting incline.

4th.—Length makes no difference in the output or cost further than the increased upkeep of the road, whereas the difficulties in the way of drawing with a "cousie" increase with the length.

5th.—Much less expenditure is required in making benches, as no long trains require to be collected on the incline as in a cousie.

6th.—The cost for chains is less than for ropes, as a good chain will last from twelve to eighteen years.

The following paper, by Dr T. G. Nasmyth, on "The Air of Coal Mines," was then read by the Secretary:—

THE AIR OF COAL MINES.

By T. G. NASMYTH, D.Sc., Edin., M.B. and C.M.

THE sanitary examination of air has lately attracted more attention than it probably ever has at any former period. Although we have now abundant literature bearing on the air of houses—one-roomed, two-roomed, and four roomed—sewers, hospitals, and schools; yet, since the late Dr. Angus Smith published his valuable work on *Air and Rain*, in which there are accounts of very long and important experiments on the air of mines, I have not been able to trace any published work on the air of mines. Dr. Smith's observations were made in the year 1863, and since then the methods of coal mining, including ventilation, have been completely altered, so that the air of the mine of to-day may be totally different from what he experienced. As I have been born and brought up in a mining district, the subject was one that naturally interested me, and the further fact that for ten years I have been medical attendant to several large collieries has given me facilities for studying it from what may be called chemical and pathological points of view. No reasons are given to explain why the subject should be carefully inquired into, as I presume they are self-evident.

Anyone who has read Dr. Smith's work will agree with me that the conditions which he found existing in mines were bad. Without entering into any details or discussions as yet into his observations, I simply shall mention that, taking carbonic acid as a test and an example of the state of air found, from 339 specimens taken he got an average of 0·785 per cent. No miner at the present time would be asked to work in such an atmosphere, nor would he if asked. From fifteen to twenty years ago mine air was bad. Improved methods of ventilation were not then in general use, and the law on the subject was not so strictly enforced as now, when not only must there be ample provision for removal of the air, but measurements must be periodically made and entered into a book for the purpose, showing the volume and the velocity of the fresh air currents. The test of a candle or a lamp burning is a somewhat rough one, as it is made by the miner. When made in the manner referred to by

Smith it is of more value, but the miner's method is a common one, and in "fiery" pits often such a fatal one, that some reference to it may be interesting.

In talking with miners on the subject, they have told me that about twenty years ago the air was sometimes so bad that, if the lamp were unaided, it would not burn, but by constant attention it might be made to give out a feeble light, and it was frequently the duty of boys when too young or too small for harder work to trim the lamps, and keep them burning for their fathers or seniors. This is a rude test, but at the same time impresses one with the idea that the air must have been very bad. Judging from my own experience and sensations, a very short time in a "waste" where lamps would not burn was decidedly unpleasant, and one longed for fresh air in a way hitherto unexperienced. The candle I shall refer to when the methods of examination are described.

Methods of Examination.—In a purely scientific investigation, other methods might have been selected, but the primary object of the inquiry being to ascertain the relationship between mine air and the miners' health, some variations are made. It must be further borne in mind by those who have not attempted this sphere for research, that they must be prepared to meet with difficulties in mines which they would not experience elsewhere, such as absence of the light of day, limited space to work in, constrained position, risk, and injury to apparatus used. I am happy to say I cannot add difficulties put in my way, as, from miner to master, every facility was given me in my work. The growth of the microbes in Hesse's tubes was an object to the workmen of great interest and of exaggerated importance, as bearing on imagined diseased conditions attributed to these—in so many cases—harmless organisms.

Temperature of Mines.—To the meteorologist, an accurate record of the temperature of mines would doubtless be interesting, and I am not aware any have been made. The difficulties and want of facilities for making them are sufficient reasons, apart from the dangers to which valuable instruments are liable in mines. The charts I have made are not valuable to the meteorologist, as they neither show the maximum nor the minimum temperatures, but show the

temperatures of the wet and dry bulb thermometers at a fixed hour of the day, namely, 9 A.M. The readings were made by a highly intelligent and conscientious mine inspector whom I instructed and supervised in the readings. The readings made above ground were made by myself at the same hour of the day, for comparison with the underground thermometers.

Estimation of Ammonia.—I am sorry to say this was only an attempt, and for many reasons had to be given up. The greatest difficulty was the cumbersome apparatus, aspirator and bottles with distilled water, and the long time consumed over the process. The method followed was that of Wanklyn, Chapman, and Smith.

Determination of Organic Matter.—There can be no doubt that the estimation of ammonia and albuminoid ammonia is the best test we yet have in obtaining from the amount of these products the amount of organic matter, but for reasons already given this method had to be given up, and the other methods suggested were the varieties of the permanganate process. The method used by Angus Smith was this: a known quantity of air is drawn through a solution of permanganate of known strength, and the amount of permanganate undecomposed is determined by oxalic acid. The method is open to many objections, for complication of apparatus, time needed, and uncertainty of results. The variety of the permanganate method I used is that of Professor Carnelley, to whom I beg to express my great indebtedness for his kindness in giving me copies of his various papers on the air of schools, sewers, &c., and in which the method is described. As this method is not generally known, I shall quote a description of the process from his pamphlet—a reprint from the *Transactions of the Royal Society*, June 10th, 1886:—

Professor Carnelley's Method of determining Organic Matter.—The principle is reduction of potassium permanganate. The amount is determined colorometrically by comparison with a standard. The solution of permanganate used is of $\frac{N}{1000}$ strength, of which 1 cc. = 0·008 milligrams of oxygen = 0·0000056 litre of oxygen at 0° and 760mm. It is usually kept $\frac{N}{10}$ strength, and diluted as required, about 50 cc. of dilute sulphuric acid being added to each litre of

weak solution. The samples of air are collected in well stoppered jars of about 3·5 litres capacity. The jars are filled by pumping out the air contained by bellows, and allowing the air examined to flow in. 0·50 cc. of standard permanganate are then run into the jar, which is then tightly stoppered and well shaken for at least five minutes. 25 cc. of the permanganate are then withdrawn by a pipette, and then placed in a glass cylinder holding about 250 cc. Then 25 cc. of the standard permanganate are run into a similar cylinder; both are diluted up to about 150 cc., and allowed to stand for about ten minutes, after which the tints of the cylinders are compared. Standard solution is then run into the decolorised solution from a graduated burette, until the tints of both cylinders are of the same intensity. The amount of solution added from the burette is a measure of the bleaching effected by the known volume of air on half the permanganate. This multiplied by 2 gives the amount. The results may either be expressed in terms of the number of cc. of the $\frac{N}{1000}$ bleached by one litre of air, or by the number of volumes of oxygen required to oxidise the organic matter in, say 1,000,000 volumes of air. Example :—25 cc. of solution from a 3·5 litre jar, in which 50 cc. had been used, required 3 cc. of permanganate to bring it up to the standard, or the whole 50 cc. would have required $3 \times 2 = 6$ cc. This represents the number of cc. of standard permanganate bleached 3500 − 50 cc. = 3450 cc. of air, consequently $\frac{6}{3.45} = 1{\cdot}74$ cc. is the bleaching effected by one litre of air. But 1 cc. of KMN04 = 0·0000056 litre of oxygen ; ∴ 1.74 cc. KMN04 = 0·0000056 × 1·74 = 0·0000097 litre of oxygen is required to oxidise the organic matter in 1 litre of air, or 9·7 vols. of oxygen to oxidise the organic matter in 1,000,000 vols. of air.

The method is highly ingenious, and can be rapidly performed. Some difficulty is experienced at first in matching the tints, and with some samples of mine air, no amount of standard would bring the decolorised sample up to its colour. For the purposes to which Professor Carnelley applied this method, it has many things to recommend it; but for the air of mines, those objections to which the permanganate method is liable render the test unsatisfactory as a test for organic matter ; but as a test for organic matter and other impurities co-existing, it is a most useful

test. In mines we have those various substances existing which, as well as organic matter, decolorise the permanganate solution, such as sulphuretted hydrogen, nitrous acid, sulphurous acid, &c., from the combustion of gunpowder, dynamite, and burning of lamps. The results I obtained were very high in many cases, and this I attribute to the presence of these compounds, as well as to the organic matter. Professor Carnelley refers specially to the effect of oil lamps ; and in mines where many hundreds are burning during work, it is no surprise that my results are high, even from this cause alone. In Carnelley's experiments he found, before burning of lamps, oxygen per 1,000,000 vols. to be 8·7, while, after, it had risen to 18·1.

Estimation of Carbonic Acid.—The method adopted was that of Pettenkoffer. The samples were collected in Winchester quarts, and an ordinary pair of bellows, with a tube attached to the spout long enough to reach the bottom of the bottles, was used to fill them with the air desired.

Estimation of Oxygen.—The method I have used is that of Franks of Berlin, and the apparatus is associated with his name, —Franks's burette. It consists of a burette graduated into 50 cc., and with a bulb on either end. One end is closed by a stopcock, the other by a plug on which there is also a stopcock. This plug closes the bulb on one end. Between this bulb and the graduated part of the burette is a stopcock with wide bore. The burette is filled by allowing the air to be examined to stream through it. The two stopcocks are then closed. A quantity of water sufficient to fill the bulb at the end where the plug is inserted is introduced. The burette is then inserted into a tall cylinder of water, till the level of the water in the bulb and the cylinder is the same. The stopcock with wide bore is then opened, and by this means a volume of air at ordinary atmospheric pressure is obtained. The stopcock is now closed, water run out of the bulb, and an alkaline solution of pyrogallic acid is run into the bulb sufficient to fill it completely. The plug, open, is then inserted, and stopcock closed ; then the stopcock with wide bore is opened, and the absorbing solution is allowed to run into the graduated part, where it is slightly shaken. The solution is then run back to the bulb, and the stopcock closed. After this the absorbing

solution is run out entirely, the bulb washed out with water, finally filled with water, and the plug inserted. The burette is then placed in the tall cylinder of water, and the stopcock with wide bore opened, the height of water in the burette is read off at the same water level as of the cylinder, and this gives the volume of oxygen per cent. The volume is then calculated for temperature and pressure. I cannot vouch for the accuracy of the instrument, but it is very handy, and at least gives comparatively accurate results.

Method for Estimation of Micro-Organisms.—The method of Hesse is by far the best in present use, and this was the one used by me. Koch's own method is useful so far, but the results are not quantitative. When specimens only are desired, and not an idea of the number for a given volume of air, Koch's method is useful, likewise the method of simply exposing plates with nutrient jelly to the air to be examined, or sterilised potatoes, bread, &c.

Hesse's Apparatus.—This consists of a glass cylinder about 18 inches long and 2·2 inches in diameter. At one end a piece of india-rubber sheeting is stretched and firmly bound round the end of the glass cylinder to prevent air sucking past it. The other end of the glass cylinder is closed with a tight-fitting plug of india-rubber, through which a glass tube passes. From this tube passes a piece of india-rubber tubing to a litre bottle filled with water, and from this bottle to a second litre bottle another tube passes; when not in action this tube is pinched off. Along the bottom of the glass cylinder are 50 cc. of nutrient jelly solid when cooled. The cylinder rests on a tripod stand similar to those used by photographers. The nutrient jelly, india-rubber caps, tubing, cylinder, &c., are sterilised in the usual manner by steaming in a steriliser repeatedly, and the tubes with their layers of jelly are kept sufficiently long before using to see that there is nothing growing on them. When we wish to operate, the india-rubber sheeting is perforated by a heated needle or pin making a very small hole, and the pinchcock is screwed slack; water passes slowly from the upper to the lower bottle, and when it is empty, a litre of air has been supposed to pass into the cylinder, and to deposit its contained microbes. As many litres of water

as desired can be run out simply by reversing the position of the bottles. When the air is very foul one litre will be sufficient as the colonies otherwise would be too close and run into each other. When the operation is over, sterilised india-rubber caps or pieces of cotton-wool, also sterilised, are bound over the ends of the Hesse tube, and it is then placed in either an incubation chamber or other suitable place. After a week or ten days longer the colonies may be counted. At one time the glass cylinders were used with a coating of jelly all round the interior, but this is difficult to obtain, and in practice it is found that the microbes gravitate and settle on the layer on the bottom of the tubes. The method of Hesse is very elegant, and has many advantages: from the length of the surface of the jelly exposed separate colonies form, often giving pure cultivations, and their growth can be studied as on a glass plate, and inoculations can readily be made in the usual manner. There are, undoubtedly, objections, some of which apply to all bacterial methods, and others which apply specially to this. One in particular, struck me, and I have not heard it referred to by any other. It is this: Although you run off a litre of water, and although the capacity of the glass cylinder is also about a litre, it does not follow that a litre of air has been drawn from the outside. The first half of the air contained in the glass cylinder may be removed, but after that, or even before it, the air from the outside and the air inside diffuse and commingle, so that a mixture of these will be aspirated out, and in consequence a litre of air will not have passed in. There can be little doubt about this, so that as a quantitative test the method is defective. Another objection is that you cannot be sure all microbes are deposited; true, we find in practice that the colonies are found in greatest abundance at the end furthest from the aspirator, and gradually diminishing inwards. Tyndall's researches bring out this point, and if we directed the beam of an electric light into one of those tubes, doubtless we would find floating particles long after we expected. Notwithstanding these objections the method is the best we have, and likely to remain so for some time.

Methods of Ventilation.—An inquiry regarding the condition of the air of mines would be incomplete without reference being

made to the methods adopted to secure purity. Ventilation implies two conditions: removal of impure and the substitution of pure air, and those conditions may be obtained either by, first, natural methods, such as by the action of winds, changes produced by alterations in temperature or pressure, or by the diffusive tendencies of gases; secondly, artificial methods. We have such examples as the action of fires, fans, jets of steam, steam pipes, &c. The principles of these, however, are not different from natural methods. In the cases of those mines which came under my notice, the kind of artificial method adopted was the fan method applied on the principle of propulsion. Whether the propulsion method or the vacuum method is the better I cannot decide, and this point falls more under the consideration of mining engineers.

However efficient a ventilating fan may be or powerful the motive power, the combined efforts may be defeated by defective stoppings or injudicious splittings, or other defects of the various ingenious methods used. I can only speak of the various mines I have personally examined, and the experience obtained so far has been expressed by the results of the numerous chemical examinations made. The conclusions drawn from these have been already stated, and show the generally satisfactory state of the air. What now remains is to show from actual measurements by the anemometer the quantity of air passed into those mines which were examined by me.

Volume of Air measured by Anemometer.

——	Cubic Feet per Minute.	Section Area of Course.
Moderately deep mine, ...	14,345	—
,, ,,	14,784	—
,, ,,	12,730	—
,, ,,	13,065	—
,, ,,	9,900	—
,, ,,	8,000	—
,, ,,	7,590	—
Deep Mine, ...	50,400	16 × 7
,,	50,624	—
,,	51,520	—
,,	52,080	—

In the following Table the Effect of Underground Stables will be shown as regards CO_2 Oxidisable Matter and Micro-Organisms.

Carbonic Acid per 1,000.	Oxygen, per 1,000,000.	Microbes per Litre.	Remarks.
2·175	—	Countless	In stables.
0·489	—	—	Near bottom.
0·610	—	—	Past stables.
—	—	Sixteen points	Near stables.
—	35 vols.	—	—
—	Matchless	Countless	In stables.
1·757	16	—	Front of stables.
1·778	20	—	Past stables.
2·205	27	—	Front of stables.
2·595	32	—	Past stables.
2·111	30	150 moulds, 50 bacteria	Stables.
1·454	10	Numerous moulds	,,
1·675	Matchless	30 moulds, 30 bacteria	1 horse in stable.
1·280	50	—	Outside stables.
2·586	Matchless	—	24 ponies in stables.
2·630	60	—	Ponies in stables.
2·209	45	—	Beyond stables.
2·796	30	—	Stables full.
3·025	60	—	12 ponies in stables.
2·404	—	—	Stables.
7·000	—	—	Stables in upcast.
7·8	—	—	—
1·15	—	—	Front of stables.
2·4	—	—	Past stables.

Table shewing Effect of Distance.

Carbonic Acid per 1000.	Oxygen, per 1,000,000.	Microbes per Litre.	Remarks.
0·489	—	—	Near bottom.
0·610	—	—	Further in.
1·085	—	—	150 yards in.
2·55	—	—	2,000 ,,
2·59	—	—	,, ,,
1·906	—	—	,, ,,
1·339	—	—	,, ,,
2·112	34	—	1,700 ,,
2·868	25	—	1,900 ,,
0·964	11	25	100 ,,
1·641	13	30 bacteria, 10 moulds	400 ,,
1·822	50	—	—
1·637	60	—	700 yards in.
3·286	—	20	1,500 ,,
1·604	—	24	1,000 ,,
1·470	—	—	500 ,,
7·000	—	—	Temperature, 70° F.
4·209	—	—	1,500 yards in.
2·00	—	—	1,000 ,,
1·187	Matchless	—	100 ,,
1·653	33	—	,, ,,
5·182	40	None	Temperature, 70° F.
1·656	33	—	100 yards in.
3·025	60	—	Stables.
1·912	22	14 bacteria, 2 moulds	1,000 yards in.
1·266	32	—	100 ,,
—	52	—	400 ,,

It will be noticed how much the quantities vary in these tables, but the stables referred to were in four different pits, some situated in the downcast and some in the upcast shaft, and different depths in each. The effect will be seen by the increase of carbonic acid when the air is in the stables or past the stables. The organic matter is also increased by the stables, and micro-organisms I have invariably found to be enormously increased when the samples were taken in the stables. A suggestion naturally follows that, when possible, stables should be placed in the upcast shaft, as the air from the stables when in the downcast shaft must undoubtedly diffuse all over the mine, and vitiate it seriously. More attention should be directed to keep the stables as clean and sweet as possible by having impervious floors, and by the use of a liberal supply of water to sweep out impurities. Moss litter has been found to have a good effect in improving the air, probably by absorbing ammonia.

In the last Mines Act a clause occurs by which it is ordered that stables must be ventilated by a current of air passing round them. This in the interests of the ponies is satisfactory, but if the stables were better constructed and kept cleaner, the effect on the general conditions of the air would be beneficial.

These samples were taken from different mines. The shallow ones are the first on the list. The general effect will be seen in the almost uniform increase of the carbonic acid as the distance from the bottom of the downcast increases. In shallow pits the air at the bottom of the downcast is very good indeed, but in the deep pits I never found a sample as good as in a shallow one, as was to be expected. The oxidisable matter varies, but there are so many substances which act on the permanganate, that the effect must be variable. The micro-organisms do not seem to follow any fixed rule, as in one very bad sample as regards CO_2 there were none, and the next time I made an examination of the same air I got about twenty bacterial points per litre. Stagnation of air and high temperature are favourable circumstances to their growth, but the presence of horses or men is more so.

Table shewing Relationship of CO_2 Oxygen per 1,000,000 Vols. and Microbes.

Carbonic Acid per 1000.	Oxygen per 1,000,000.	Microbes per Litre.
1·397	42	214 moulds 10 bacteria
2·111	30	150 ,, 50 ,,
5·812	—	63 ,,
—	20	41 ,,
1·267	—	26 ,,
0·820	—	16 ,,
0·811	—	25 ,,
2·175	—	countless
2·562	—	6 bacteria
2·303	—	5 ,,
8·790	—	0 ,,
2·630	60	—
2·209	45	—
2·796	30	—
1·187	matchless	—
2·856	39	—
1·352	15	—
1·912	22	16 bacteria
5·182	40	0 ,,
2·628	30	28 bacteria
0·964	11	25 ,,
1·454	10	countless
1·675	matchless	30 moulds 30 bacteria
2·063	34	17 ,,
1·641	13	10 moulds 30 bacteria
3·286	—	20 ,,
1·604	—	24 ,,
—	matchless	jelly liquid
6·000	—	5 moulds 4 bacteria
7·000	—	4 ,, 111 ,,
,,	—	5 ,, 20 ,,
1·912	22	2 ,, 14 ,,
2·628	30	4 ,, 24 ,,
2·4	—	25 ,,
2·517	—	—
1·358	—	—
2·872	—	—
2·832	—	4 moulds 10 bacteria
2·4	—	—
1·15	—	3 ,,
4·445	—	3 ,, 20 ,,

In the following table the carbonic acid is alone estimated, and the samples do not represent the condition of mines, seeing that they were collected in "wastes," upcast shafts, and generally where no work was going on. The effect of barometric depression was noted on several occasions; samples were collected always at the same place in a mine, and compared with samples collected when the barometer was steady or standing high.

Carbonic Acid per 1000.	Remarks.
5·812	Made in waste, no current, lamps dim.
3·811	In mine after explosion of blasting powder.
3·4	Upcast shaft.
3·5	Do.
4·066	Do.
4·012	Do.
11·050	Taken in mine where fatal case had occurred.
3·025	In stables with twelve ponies in.
5·182	In foul shaft, 1,500 yards in.
3·377	—
6·000	Bottom of upcast shaft.
7·000	Do. do.
3·286	1,500 yards from bottom of shaft.
7·000	Barometer rising after fall.
4·579	Low Barometer.
4·8	Do.
7·581	Do.
7·261	Barometer rising after severe fall.
6·999	Do. do.
5·182	Barometer high.
20·000	Air passing from burning seams.
80·000	Air in mine closed for burning seam.

Table showing Percentage of Oxygen.

Oxygen per Cent.	Remarks.
20·3	Sample taken 1,500 yards from downcast.
20·2	Do. 1,000 do. do.
20·6	Bottom of pit.
20·3	Stables in pit.
20·4	50 yards from bottom.
20·3	Do. do.
20·1	Bottom of upcast shaft.
19·8	Stables in upcast pit, temperature 68° F.
20·4	Sample 1,500 yards from downcast.
20·6	Do. 1,000 do. do.
20·6	Do. 500 do. do.
20·0	Do. 1,000 yards in, temperature 70° F.
18·0	Stythe from burning coal.
20·4	1,500 yards from downcast.
19·9	Outside stables in upcast pit.
19·4	Inside do. do.
19·1	1,000 yards in upcast, temperature 70° F.
18·9	Do. do. do.
4·0	In this sample there was 80 per cent. of CO_2. Seams on fire and section built up.

Results Compared.

Carbonic Acid per Cent.	Oxygen per 1,000,000 volumes.	Oxygen per Cent.	Situation.	Authority.
0·181	30	—	Shallow mines.	—
0·219	39	20·40	Deep mines.	—
—	—	20·26	,,	Smith.
0·785	—	—	—	,,
0·10	—	—	Barracks.	Chaumont.
0·216	—	—	Schools.	Endeman.
0·245	—	—	,,	Weaver.
0·112	—	—	One room house.	Carnelley.
0·099	—	—	Two ,, ,,	,,
0·077	—	—	Four ,, ,,	,,
0·186	—	—	School.	,,
0·123	—	—	,,	,,
0·133	—	—	Factory.	,,

Table showing Average of Results.

	Per Cent.
Carbonic acid in moderately deep mines, ...	0·181
Carbonic acid in deep mines over 100 fathoms, ...	0·219
Oxygen in deep mines, ...	20·40
Oxygen required to oxidise 1,000,000 volumes of air—	
Moderately deep mines, ...	30
Deep mines, ...	39

Those are exceptionally high results, and they do not represent the average condition of mines. In the case of the last estimation, which gave 80 CO_2 per 1000 volumes of air, the sample was taken from a mine which had been purposely closed for a month or two, and as nearly hermetically as possible, so as to damp off a burning seam by using up the oxygen and developing carbonic acid. In practice this method alone is found sufficient. Before the place was opened I warned the workmen of the danger of going in. Lights went out at once when introduced. No one ventured in, but still it was possible to collect the samples I got, from the fact that a current of fresh air passed up to the door which closed up the mine. The bottles were introduced through this and emptied of their contained water—the only method applicable in this case.

The sample which showed 11·050 per 1000, had a history attached to it, as in the place where it was collected, an hour before a man had succumbed to the poisonous gases given off from the burning seam referred to. The air here smelt of the combustion

of coal, paraffin or naphtha being the most apparent. The quantity of carbonic acid, though large, doubtless did not cause death, but as there would be carbonic oxide as well, the cause of death was not far to seek. Lamps burnt well enough, and this would probably be assisted by some marsh gas given off from the burning coal. The effect of these gases on individuals is peculiar; some men were overcome at once, others were not very susceptible.

As I accompanied the rescue party with the hope that artificial respiration might not be too late to restore the man, I can speak from experience of the effect produced.

The action of the heart was increased, not from the excitement of the situation, I believe, as I again experienced this on a second visit, with some slight oppression of breathing and giddiness, and a tightness over the forehead as long as I remained in the foul place. There was not much else to be felt, but on reaching the fresh air there was very marked giddiness, weak fluttering action of the heart, and almost syncope, followed by severe headache and thirst. The experience of others was similar, with pain in the loins, and loss of power of the limbs, and, in those overcome, unconsciousness, and vomiting on return to consciousness. Those symptoms look like poisoning by carbon disulphide, and no doubt this is present in the stythe from the burning coal. In regard to the relationship that exists between barometric conditions and the presence of explosive gases in mines, it is usually stated that with a low barometer there is danger of explosions, but there is as much with a variable condition of the barometer, and especially with a rise subsequent to a low barometer. The mines I have examined are not fiery, hence I could not trace any relationship such as the above, and as there is no very good method of examining carburetted hydrogen accurately, I cannot speak regarding this connection; but assuming that carbonic acid gas might be used as an indicator of other gases, I have examined the quantities of carbonic acid at a fixed place at a mine under those varying conditions referred to, and I certainly found that with a low barometer, or with a rising one, I got much larger quantities present than when the barometer was steady or high. At the place I selected for testing the point, the quantity of car-

bonic acid usually found was from 3 to 4 volumes per 1000 with a low barometer, or with a rising one after a fall I got from 5 to 7 volumes per 1000. This part of the subject demands further attention, which I hope yet to give it.

Micro-Organisms in Coal Mines.—Hesse's process is useful, both as a convenient method for collecting and estimating the number of colonies in a given quantity of air, but also to enable us to observe any special features in the growth of these colonies, and from them further to make pure cultivations when so desired. The conditions of growth in the air of mines are totally different from those found above ground, in the absence of sunlight, the presence of excessive moisture, and the different chemical nature of this underground atmosphere.

I have already stated that I did not find a uniform connection between impurity of air and quantity of organisms found. There seem to be various modifying circumstances contributing to these results. Where the current of air was strong there were usually few colonies found, and when the air was stagnant, there colonies were abundant. The presence of men and horses has a very great influence in affecting both the numbers and kind of colonies, increasing the former and varying the kind; where there were neither horses nor men, usually there was a crop of moulds; where men and horses were near, there bacteria were got.

General Description of Microbes Found.

A. Sample made at upcast shaft, very foul air. The slides were mainly torulæ, mycelial filaments, bacilli subtiles, and some cocci. Number of colonies, 26.

B. Bottom of downcast. Torulæ and mycelial forms alone. Number of colonies, 15.

C. Upcast; bacilli, torulæ, and mucors.

D². Upcast in deep mine very foul air. 5 penicillia, 4 bacteria.

E². Stables in upcast, air very bad. Moulds 10, bacteria 110.
Slides : bacilli, torulæ, and micrococci.
Cultivations : 1. Orange yellow in jelly.
2. Pure white.
3. „ „
4. Yellowish.

F². Bottom of upcast, foul air. Bacteria 20, moulds 5.
Slides : micrococci, torulæ, and bacilli.

G². Stables in downcast pit. 25 penicillia glauca.

H². 1,000 yards from downcast. 24 colonies.
In 10 slides : bacilli, micrococci.
I². 1,500 yards from downcast. Colonies 20.
K². 1,000 yards in. 24 points.

F. Sample made in stables.
In 10 slides there were bacilli, cocci, torulæ, and mycelial forms. Colonies countless.

G. Sample taken 1000 yards from downcast. No work going on. Fans stopped.
In 6 slides there were mostly bacilli. 6 colonies in tube.

H. Same place as G.
In 5 slides : torulæ, micrococci, and a few bacilli. Colonies 5.

I. Sample taken in waste.
CO_2. 8 volumes per 1000. Lamps would scarcely burn.
Slides : mostly penicillium glaucum. Colonies 62.

J. 1000 yards from downcast. Colonies 12, bacterial moulds 8.
Slide 1 : Micrococci in clusters and chains, in jelly, pale straw colour forming a very deep cup into jelly.
Slide 2 : Large micrococci, bright orange in colour.
Slide 3 : Mirococci, jelly liquid. Other slides : torulæ chiefly.

K. Sample near stables. 16 colonies in all ; 4 of these moulds.
In 9 slides : micrococci and a few bacilli.

L. Samples in stables.
Slides : torulæ, micrococci, and bacilli.

M. Same place as L. Cocci, torulæ, and bacilli.

N. Made in stone mine, blind end, so little current two men working. Temperature 59° F. 41 colonies.
In 17 slides : bacilli, torulæ, cocci, and mycelial forms.

P. Sample 200 yards from downcast. 60 moulds, 4 bacterial growths.
Slide 1 : long broad bacilli arranged in clusters show spores ; others, cocci and torulæ.

Q. 500 yards from downcast. 8 moulds and 4 bacteria.

R. Made in stables. Colonies countless.

S. Bottom of pit. No work going on for four days ; fan not going. Moulds 214, bacteria 10.
Slide 1 : mycelial growth.
Slide 2 : torulæ and bacilli, bright orange growth in tube cultivation.
Slide 3 : pinkish growth in jelly, long bacilli at ends.
Slide 4 : Micrococci, white growth in jelly.
Slide 5 : large micrococci, bright yellow growth in jelly.
Slide 6 : orange growth in jelly, large micrococci.

T. Made in stables. Moulds 150, bacteria 50.
Slide 1 : impure mycelia and micrococci.
Slide 2 : micrococci, pearly white growth in jelly.
Slide 3 : micrococci or torulæ, straw coloured growth in jelly.

Slide 4 : jelly liquefying micrococci.
Slide 5 : large micrococci, orange growth in jelly.
Slide 7 : large bacilli like bacillus anthracis, jelly liquid.
Slide 9 : straw coloured growth, cup-shaped and yellow in colour, micrococci.
Slide 10 : micrococci, jelly liquid.

U. Made in stables. Moulds countless.

V. Samples opposite stables in pit. 150 fathoms deep near downcast. 25 colonies.
Slides : bacilli and micrococci.

W. Stables of deep pit. Moulds 3, bacteria 30.
Slides : bacilli, torulæ, and mucor growths.

X. Near downcast deep pit. 17 colonies.
Slides : micrococci, torulæ, and bacilli.
Cultivations four in number.

Y. Sample 400 yards from downcast. 10 moulds, 30 bacteria.
Slides : micrococci, torulæ.
Cultivations seven in number.

A[1]. Sample made in *cul-de-sac* 1000 yards from downcast. Moulds 4, bacteria 24.
Slides : nearly all micrococci.
Cultivations : 1. Pearly white growth on surface forming a ring round a central growth.
2. Delicate pink in jelly.
3. Liquefying.

B[2]. 1000 yards from downcast. Temperature 60° F. 14 colonies. Bacilli and micrococci.

C[2]. 1500 yards in. No growth at all.

D[2]. Made in upcast. 5 penicillia, 4 bacteria. Consisting of micrococci.

E[2]. Stables in upcast. Moulds 10, bacteria 110.
Slides 8 in number, showing bacilli, torulæ, and micrococci.
Cultivations : 1. Impure.
2. Pure white growth in jelly, small round cocci.
3. Same as No. 2.
4. Yellow growth, cocci in clusters and chains.

F[2]. Bottom of upcast. Bacteria 20, moulds 5.
In 10 slides : micrococci, torulæ, and bacilli.

H[2]. 1000 yards from downcast. 24 points.
10 slides : mostly micrococci, some show bacilli.

I[2]. 100 yards from bottom of downcast. 4 points.
Slides show micrococci and mycelial forms.

K[2]. Samples in stables. 30 penicillia, 20 bacteria.
8 slides : mostly micrococci and bacilli.

Underground Temperature.—I have already mentioned the plan that was adopted, and that the results are not intended to be at all strict meteorological records, but simply to show as near as possible the average temperature of a mine at a fixed time of the day. The thermometers, wet and dry bulb, were put in the airway, through which the air coming from the surface had travelled 1000 yards. The observations began in September, 1887, and terminated January, 1888.

Peculiarities of Records.—The highest temperatures recorded were on September 9th, when 55° F. was indicated at the thermometer above ground ; in the mine the temperature was 55·5°. The lowest temperature above was on December 22nd, 25° ; in the mine on the day the temperature was 53°. The smallest difference between the temperatures above and below occurred on September 9th, when the temperature in the mine was only half a degree higher than above ground. The greatest difference was on December 22nd, when the temperature was 28° higher below than on the surface. The highest temperature in the mine was 55·5°. The lowest temperature in the mine was 53°, and this temperature was recorded on twenty-one consecutive days, showing an extraordinary uniformity of temperature. The greatest difference below was 2·5°. The greatest difference above in two consecutive days was 14°, while below it was only 1°. The relative humidity below varied from 93° to 100° ; practically the air is nearly always saturated. This excessive humidity is certainly not desirable from a sanitary point of view, but I do not know any bad consequence to the health of the miners. The uniformity of temperature is certainly favourable ; there are not the great vicissitudes of temperature as above ground, nor the biting blasts.

It is a fact well known that ponies and horses soon improve in condition in mines ; their coats shine in a way which can only occur with much grooming above ground, and which they certainly do not get below ; and in spite of hard work I have known ponies to be twenty years below ground, and at a time when the ventilation was very bad and the working hours longer than now. The chart showing the whole range of temperatures from September to January will be found on Plate V.

In the following Tables the Temperatures of Wet and Dry Bulb Thermometers on the Surface are compared with the Readings Below at a Distance of about 1,000 *yards from Bottom of Pits.*

Month.	Above.			Below.			Difference.			
							Above.		Below.	
	Dry Bulb.	Wet Bulb.	Rel. Hum.	Dry Bulb.	Wet Bulb.	Rel. Hum.	Temp.	R. H.	Temp.	R. H.
	°	°		°	°		°		°	
Sept. 8	54·0	49·0	69	55·0	54·0	93	—	—	+ 1·0	+24
„ 9	55·0	54·0	93	55·5	54·5	93	—	—	+ 5·0	—
„ 10	48·0	46·3	86	55·0	54·0	93	—	—	+ 7·0	+ 7
„ 11	49·3	48·7	93	55·0	54·7	93	—	—	+ 5·7	—
„ 12	49·0	48·0	93	55·0	54·2	93	—	—	+ 6·0	—
„ 13	45·3	43·0	85	55·0	54·0	93	—	—	+ 9·7	+ 8
„ 14	49·0	47·5	86	55·0	54·0	93	—	—	+ 6·0	+ 7
„ 15	47·0	45·5	86	54·5	54·0	93	—	—	+ 7·5	+ 7
„ 16	47·7	46·5	93	55·0	54·5	93	—	—	+ 7·3	—
„ 17	52·0	50·1	86	54·5	54·0	93	—	—	+ 2·5	+ 7
„ 18	48·3	46·5	86	—	—	—	—	—	—	—
„ 19	49·0	47·0	86	54·5	54·0	93	—	—	+ 5·5	+ 7
„ 20	48·3	47·0	93	54·0	53·3	93	—	—	+ 5·7	—
„ 21	49·4	48·5	93	54·5	54·0	93	—	—	+ 5·1	—
„ 22	50·5	49·0	86	54·0	54·0	100	—	—	+ 3·5	+14
„ 23	50·0	49·1	93	55·0	54·3	93	—	—	+ 5·0	—
„ 24	48·0	47·5	86	54·5	54·3	93	—	—	+ 6·5	+ 7
„ 25	51·7	51·0	93	—	—	—	—	—	—	—
„ 26	53·2	53·2	100	54·5	54·0	93	—	+7	+ 1·3	—
„ 27	—	—	—	54·0	53·5	93	—	—	—	—
„ 28	41·0	40·0	92	53·5	53·0	93	—	—	+12·5	+ 1
„ 29	48·5	48·3	100	54·0	53·5	93	—	+7	+ 5·5	—
„ 30	50·0	48·0	86	54·0	53·5	93	—	—	+ 4·0	+ 7
Oct. 1	45·3	45·0	100	54·0	53·5	93	—	+7	+ 8·7	—
„ 2	—	—	—	—	—	—	—	—	—	—
„ 3	—	—	—	54·0	53·7	100	—	—	—	—
„ 4	46·0	44·5	86	54·0	53·5	93	—	—	+ 8·0	+ 7
„ 5	46·5	45·3	93	54·0	53·5	93	—	—	+ 7·5	—
„ 6	49·0	48·0	93	54·0	53·5	93	—	—	+ 5·0	—
„ 7	45·0	44·5	92	54·0	53·5	93	—	—	+ 9·0	+ 1
„ 8	40·0	39·0	92	54·0	53·0	93	—	—	+14·0	+ 1
„ 9	38·5	37·5	91	—	—	—	—	—	—	—
„ 10	—	—	—	53·5	53·0	93	—	—	—	—
„ 11	35·0	33·3	80	53·5	53·0	93	—	—	+18·5	+13
„ 12	34·0	32·0	79	53·0	53·0	93	—	—	+19·0	+14
„ 13	40·0	38·0	84	53·0	52·5	93	—	—	+13·0	+ 9
„ 14	39·0	37·0	84	53·0	52·5	93	—	—	+14·0	+ 9
„ 15	36·5	34·3	82	53·0	52·5	100	—	—	+16·5	+18
„ 16	38·0	36·0	83	—	—	—	—	—	—	—
„ 17	36·0	35·0	91	54·0	53·0	93	—	—	+18·0	2+
„ 18	46·7	46·0	93	54·0	53·0	93	—	—	+ 7·3	—
„ 19	46·0	44·0	86	54·0	53·5	93	—	—	+ 8·0	+ 7
„ 20	48·7	46·0	79	54·0	53·5	93	—	—	+ 5·3	+14
„ 21	36·3	35·0	91	54·0	53·0	93	—	—	+17·7	+ 2
„ 22	42·0	40·0	84	54·0	53·0	93	—	—	+12·0	+ 9
„ 23	48·0	47·5	100	54·0	54·0	100	—	—	+ 6·0	—
„ 24	34·0	31·0	72	53·0	52·5	93	—	—	+19·0	+21
„ 25	33·5	31·0	78	53·5	53·0	93	—	—	+20·0	+15
„ 26	40·0	37·0	77	53·0	53·0	100	—	—	+13·0	+23

Month.	Above.			Below.			Difference.			
							Above.		Below.	
	Dry Bulb.	Wet Bulb.	Rel. Hum.	Dry Bulb.	Wet Bulb.	Rel. Hum.	Temp.	R. H.	Temp.	R. H.
	°	°		°	°		°		°	
Oct. 27	49·0	49·0	100	54·0	53·0	93	—	+7	+ 5·0	—
,, 28	46·0	44·0	86	54·0	53·0	93	—	—	+ 8·0	+7
,, 29	40·3	40·0	100	54·0	53·0	93	—	+7	+13·7	—
,, 30	38·2	37·2	91	—	—	—	—	—	—	—
,, 31	40·1	39·9	100	54·0	53·0	93	—	+7	+13·9	—
Nov. 1	43·7	41·0	78	54·0	53·5	93	—	—	+10·3	+15
,, 2	43·0	41·5	84	54·0	53·0	93	—	—	+11·0	+ 9
,, 3	41·5	40·0	100	53·0	52·5	93	—	+7	+11·5	—
,, 4	37·3	37·0	100	53·0	52·5	93	—	+7	+15·7	—
,, 5	—	—	—	54·0	53·0	93	—	—	—	—
,, 6	43·0	43·0	100	—	—	—	—	—	—	—
,, 7	43·0	43·0	92	54·0	53·0	93	—	—	+11·0	+ 1
,, 8	44·0	44·0	100	54·0	53·0	93	—	+7	+10·0	—
,, 9	41·1	41·0	100	54·0	53·0	93	—	+7	+12·9	—
,, 10	36·0	35·0	91	54·0	53·0	93	—	—	+18·0	+ 2
,, 11	39·1	39·0	92	53·0	53·0	100	—	—	+13·9	+ 8
,, 12	37·5	36·0	91	53·0	53·0	100	—	—	+15·5	+ 8
,, 13	37·5	36·1	91	—	—	—	—	—	—	—
,, 14	34·0	33·0	89	54·0	54·0	93	—	—	+20·0	+ 4
,, 15	28·0	27·0	93	53·0	53·0	100	—	—	+25·0	+ 7
,, 16	34·0	33·8	100	53·0	53·5	100	—	—	+19·0	—
,, 17	39·5	37·0	84	53·0	53·0	100	—	—	+13·5	+16
,, 18	35·0	34·0	90	53·0	53·0	100	—	—	+18·0	+10
,, 19	36·0	35·8	100	54·0	53·0	93	—	+7	+18·0	—
,, 20	35·0	34·0	90	54·0	54·0	100	—	—	+19·0	+10
,, 21	36·2	36·0	100	54·0	53·0	100	—	—	+16·8	—
,, 22	39·0	39·0	100	53·0	53·0	100	—	—	+14·0	—
,, 23	36·5	35·0	91	54·0	53·0	93	—	—	+17·5	+ 2
,, 24	34·0	33·5	100	53·0	53·0	100	—	—	+19·0	—
,, 25	36·0	35·0	91	53·0	52·5	100	—	—	+17·0	+ 9
,, 26	48·0	47·0	93	53·0	53·0	100	—	—	+ 5·0	+ 7
,, 27	40·5	39·0	100	53·0	53·0	100	—	—	+12·5	—
,, 28	36·5	36·0	100	53·0	53·0	100	—	—	+16·5	—
,, 29	32·0	31·5	100	53·0	53·0	100	—	—	+21·0	—
,, 30	33·0	32·5	100	53·0	53·0	100	—	—	+20·0	—
Dec. 1	47·0	46·0	93	53·0	53·0	100	—	—	+ 6·0	+ 7
,, 2	45·0	45·0	100	53·0	53·0	100	—	—	+ 8·0	—
,, 3	45·1	45·1	93	53·0	53·0	100	—	—	+ 7·9	+ 7
,, 4	35·0	35·0	100	53·0	53·0	100	—	—	+18·0	—
,, 5	35·0	35·0	100	53·0	53·0	100	—	—	+18·0	—
,, 6	41·0	40·0	92	53·0	52·5	100	—	—	+12·0	+ 8
,, 7	31·5	31·0	100	53·0	53·0	100	—	—	+21·5	—
,, 8	32·5	31·5	100	53·0	53·0	100	—	—	+21·0	—
,, 9	34·0	34·0	100	53·0	53·0	100	—	—	+19·0	—
,, 10	27·0	—	—	53·0	52·0	93	—	—	+26·0	—
,, 11	25·0	—	—	—	—	—	—	—	—	—
,, 12	29·0	—	—	53·0	52·5	100	—	—	+24·0	—
,, 13	40·0	39·0	92	53·0	53·0	100	—	—	+13·0	+ 8
,, 14	35·0	34·5	100	53·0	53·0	100	—	—	+18·0	—
,, 15	36·0	35·0	91	53·0	53·5	100	—	—	+17·5	+ 9
,, 16	41·0	41·0	100	53·0	53·0	100	—	—	+12·0	—
,, 17	37·0	35·0	83	53·0	53·0	100	—	—	+16·0	+17
,, 18	—	—	—	—	—	—	—	—	—	—
,, 19	30·0	—	—	53·0	53·0	100	—	—	+23·0	—

Month.	Above.			Below.			Difference.			
							Above.		Below.	
	Dry Bulb.	Wet Bulb.	Rel. Hum.	Dry Bulb.	Wet Bulb.	Rel. Hum.	Temp.	R. H.	Temp.	R. H.
	°	°		°	°	°	°		°	
Dec. 20	34·0	33·0	—	53·0	53·0	100	—	—	+19·0	—
„ 21	30·0	30·0	—	53·0	53·0	100	—	—	+23·0	—
„ 22	25·0	25·0	—	53·0	53·0	100	—	—	+28·0	—
„ 23	28·0	—	—	53·0	53·0	100	—	—	+25·0	—
„ 24	34·0	32·0	79	53·0	53·0	100	—	—	+19·0	+21
„ 25	—	—	—	—	—	—	—	—	—	—
„ 26	34·0	33·5	100	53·0	53·0	100	—	—	+19·0	—
„ 27	31·5	31·0	100	53·0	53·0	100	—	—	+21·5	—
„ 28	36·5	35·0	91	53·0	53·0	100	—	—	+16·5	+ 9
„ 29	30·0	—	—	53·0	53·0	100	—	—	+23·0	—
„ 30	33·0	32·0	89	53·0	53·0	100	—	—	+20·0	+11
„ 31	31·0	31·0	—	53·0	53·0	100	—	—	+22·0	—
Jan. 1	31·5	31·5	—	—	—	—	—	—	—	—
„ 2	29·0	29·0	—	—	—	—	—	—	—	—
„ 3	33·0	32·0	—	—	—	—	—	—	—	—
„ 4	46·0	45·0	—	53·5	53·0	100	—	—	+ 7·5	—
„ 5	40·0	40·0	100	54·0	53·0	93	—	+7	+14·0	—
„ 6	36·0	35·5	100	53·5	53·0	100	—	—	+17·5	—
„ 7	40·2	40·0	100	54·0	53·5	100	—	—	+13·8	—
„ 8	48·0	48·0	100	—	—	—	—	—	—	—
„ 9	47·0	46·8	100	54·0	53·5	100	—	—	+ 7·0	—
„ 10	—	—	—	54·0	53·5	100	—	—	—	—

In the following Tables, Readings of Wet and Dry Bulbs, Thermometers on Surface are compared with Readings made at the Bottom of Pit.

Month.	Above.			Below.			Difference.			
							Above.		Below.	
	Dry Bulb.	Wet Bulb.	Rel. Hum.	Dry Bulb.	Wet Bulb.	Rel. Hum.	Temp.	R. H.	Temp.	R. H.
	°	°		°	°		°		°	
Jan. 11	44·0	43·5	100	54·0	53·5	100	—	—	+10·0	—
„ 12	33·5	33·0	89	53·5	53·0	93	—	—	+20·5	+ 4
„ 13	35·0	34·5	100	53·5	53·0	93	—	+7	+18·5	—
„ 14	35·0	34·5	100	54·0	53·5	100	—	—	+19·0	—
„ 15	—	—	—	—	—	—	—	—	—	—
„ 16	35·0	34·5	100	44·5	44·0	92	—	+8	+ 9·5	—
„ 17	33·0	32·5	100	41·0	40·5	100	—	—	+ 8·0	—
„ 18	33·5	33·0	89	42·0	41·0	92	—	—	+ 8·5	+ 3
„ 19	24·0	24·0	100	38·0	37·5	100	—	—	+14·0	—
„ 20	32·5	32·0	89	40·5	40·0	92	—	—	+ 8·0	+ 3
„ 21	42·0	41·0	92	44·0	43·5	100	—	—	+ 2·0	+ 8
„ 22	—	—	—	—	—	—	—	—	—	—
„ 23	44·5	44·0	92	47·0	46·5	100	—	—	+ 2·5	+ 8
„ 24	46·0	45·0	93	48·0	47·5	100	—	—	+ 2·0	+ 7
„ 25	47·0	46·0	93	48·0	47·5	100	—	—	+ 1·0	+ 7
„ 26	38·0	37·0	91	45·0	44·0	92	—	—	+ 7·0	+ 1

Month.	Above.			Below.			Difference.			
							Above.		Below.	
	Dry Bulb.	Wet Bulb.	Rel. Hum.	Dry Bulb.	Wet Bulb.	Rel. Hum.	Temp.	R. H.	Temp.	R. H.
	°	°		°	°		°		°	
,, 27	33·0	32·0	89	42·0	41·0	92	—	—	+ 9·0	+ 3
,, 28	28·0	27·0	—	38·0	37·0	91	—	—	+10·0	—
,, 29	—	—	—	—	—	—	—	—	—	—
,, 30	31·0	30·0	—	38·0	37·0	91	—	—	+ 7·0	—
,, 31	32·5	31·5	89	40·5	40·9	92	—	—	+ 8·0	+ 3
Feb. 1	29·0	28·0	—	39·0	38·0	92	—	—	+10·0	—
,, 2	31·0	30·0	—	38·0	37·5	100	—	—	+ 7·0	—
,, 3	38·0	37·0	91	39·0	38·5	100	—	—	+ 1·0	+ 9
,, 4	41·0	40·0	92	46·0	45·5	100	—	—	+ 5·0	+ 8
,, 5	—	—	—	—	—	—	—	—	—	—
,, 6	42·0	41·0	92	49·0	48·0	93	—	—	+ 7·0	+ 1
,, 7	38·0	37·0	91	48·0	47·5	100	—	—	+10·0	+ 9
,, 8	44·0	43·0	92	49·5	49·0	93	—	—	+ 5·5	+ 1
,, 9	38·0	37·0	91	45·0	44·5	100	—	—	+ 7·0	+ 9
,, 10	35·0	34·0	90	44·0	43·5	100	—	—	+ 9·0	+10
,, 11	31·0	30·0	—	42·0	41·5	100	—	—	+11·0	—
,, 12	—	—	—	—	—	—	—	—	—	—
,, 13	32·0	31·0	87	42·5	42·0	92	—	—	+10·5	+ 5
,, 14	30·0	29·0	—	40·5	40·0	92	—	—	+10·5	—
,, 15	30·0	29·0	—	40·5	40·0	92	—	—	+10·5	—
,, 16	28·0	27·0	—	39·0	38·5	100	—	—	+11·0	+13
,, 17	32·0	31·0	87	40·0	39·5	100	—	—	+ 8·0	+13
,, 18	34·0	32·0	79	42·5	42·0	92	—	—	+ 8·5	+13
,, 19	33·0	32·0	89	41·5	41·0	92	—	—	+ 8·5	+11
,, 20	33·0	32·0	89	42·9	41·5	100	—	—	+ 9·0	+13
,, 21	32·0	31·0	87	41·0	40·5	100	—	—	+ 9·0	+13
,, 22	32·0	31·0	87	41·0	40·5	100	—	—	+ 9·0	—
,, 23	31·0	30·0	—	40·5	40·0	92	—	—	+ 9·5	—
,, 24	32·0	31·0	87	41·0	40·5	100	—	—	+ 9·0	+13
,, 25	28·0	27·0	—	39·5	39·0	92	—	—	+11·5	—
,, 26	—	—	—	—	—	—	—	—	—	—
,, 27	37·0	36·0	91	46·0	45·5	100	—	—	+ 9·0	+ 9
,, 28	36·0	35·0	91	45·5	45·0	93	—	—	+ 9·5	+ 2
,, 29	34·0	33·0	89	44·5	44·0	92	—	—	+10·5	+ 3
Mar. 1	35·0	34·0	90	44·5	44·0	92	—	—	+ 9·5	+ 2
,, 2	33·0	32·0	89	43·0	42·5	100	—	—	+10·0	+11
,, 3	32·0	31·0	87	41·0	40·5	100	—	—	+ 9·0	+13
,, 4	—	—	—	—	—	—	—	—	—	—
,, 5	31·0	30·0	—	39·0	38·5	100	—	—	+ 8·0	—
,, 6	37·0	36·0	91	44·5	44·0	92	—	—	+ 7·5	+ 1
,, 7	45·0	44·0	92	45·0	44·5	100	—	—	—	+ 8
,, 8	46·0	45·0	93	45·0	44·5	100	+1	—	—	+ 7
,, 9	47·0	46·0	93	48·0	47·5	100	—	—	+ 1·0	+ 7
,, 10	47·0	46·0	93	48·0	47·5	100	—	—	+ 1·0	+ 7
,, 11	—	—	—	—	—	—	—	—	—	—
,, 12	29·0	28·0	—	40·5	40·0	92	—	—	+11·5	—
,, 13	31·0	30·0	—	42·0	41·5	100	—	—	+11·0	—
,, 14	29·0	28·0	—	40·0	39·5	100	—	—	+11·0	—
,, 15	29·0	28·0	—	41·0	40·5	100	—	—	+12·0	—
,, 16	27·0	26·0	—	39·0	38·5	100	—	—	+12·0	—
,, 17	26·0	25·0	—	39·0	38·5	100	—	—	+13·0	—
,, 18	—	—	—	—	—	—	—	—	—	—
,, 19	35·0	34·0	90	41·5	41·0	92	—	—	+ 6·5	+ 2
,, 20	34·0	33·0	89	41·0	40·5	100	—	—	+ 7·0	+11

Month.	Above.			Below.			Difference.			
							Above.		Below.	
	Dry Bulb.	Wet Bulb.	Rel. Hum.	Dry Bulb.	Wet Bulb.	Rel. Hum.	Temp.	R. H.	Temp.	R. H.
	°	°		°	°		°		°	
Mar. 21	39·0	37·0	84	46·0	45·5	100	—	—	+ 7·0	+16
„ 22	40·0	39·0	92	47·0	46·0	93	—	—	+ 7·0	+ 1
„ 23	38·0	37·0	91	45·0	44·5	100	—	—	+ 7·0	+ 9
„ 24	41·0	40·0	92	46·0	45·5	100	—	—	+ 5·0	+ 8
„ 25	—	—	—	—	—	—	—	—	—	—
„ 26	40·0	39·0	92	44·5	44·0	92	—	—	+ 4·5	+ 8
„ 27	42·0	41·0	92	46·0	45·5	100	—	—	+ 4·0	—
„ 28	41·0	40·0	92	54·0	43·0	92	—	—	+ 3·0	+ 8
„ 29	43·0	42·0	92	45·0	44·5	100	—	—	+ 2·0	+ 8
„ 30	42·0	41·0	92	43·0	42·5	100	—	—	+ 1·0	+ 8
„ 31	41·0	40·0	92	42·0	41·5	100	—	—	+ 1·0	+ 8
April 1	—	—	—	—	—	—	—	—	—	—
„ 2	43·0	40·0	78	42·0	41·5	100	+1	—	—	+22
„ 3	42·0	40·0	84	42·0	41·5	100	—	—	—	+16
„ 4	43·0	41·0	84	43·0	42·0	92	—	—	—	+ 8
„ 5	45·0	43·0	85	43·0	42·5	100	+2	—	—	+15
„ 6	48·0	47·0	93	45·0	44·5	100	+3	—	—	+ 7
„ 7	46·0	44·0	86	45·0	44·5	100	+1	—	—	+14
„ 8	—	—	—	—	—	—	—	—	—	—
„ 9	41·0	39·5	92	44·0	43·5	100	—	—	+ 3·0	+ 8
„ 10	45·0	44·0	92	46·0	45·5	100	—	—	+ 1·0	+ 8
„ 11	47·0	43·0	73	47·0	46·5	100	—	—	—	+27
„ 12	48·0	43·0	67	45·0	44·5	100	+3	—	—	+33
„ 13	47·0	45·0	86	47·0	46·5	100	—	—	—	+14
„ 14	46·0	44·0	86	47·0	46·5	100	—	—	+ 1·0	+14

Opinions regarding Miners' Occupation.—In endeavouring to ascertain what are the opinions regarding the effect of the conditions of employment peculiar to miners, it is found that reference must be made to periods about twenty-five years back, so that these are not likely to apply to the conditions of the present time, owing to circumstances which have been already referred to.

In Sir John Simon's *Public Health Reports*, published by the Sanitary Institute of Great Britain, we have the benefit of his unrivalled experience of the causes that act in producing disease over long periods in England and Wales; and on page 37 in vol. ii. we find the following remarks on the effect of occupation on the health of miners: "The miner, like the indoor operative, often spends his days in an ill-ventilated workplace. But the non-ventilation from which he suffers is associated in its existence and

in its consequences with conditions special to the subterranean employment, and far more complex than those which belong to the non-ventilation of common workplaces. The air in which he works is air which, for his safety's sake, ought pre-eminently to be ventilated; for in most cases not only the exhalations of human labour, but gases indigenous so the mine earth, or gases from gunpowder burnt in rcck-blasting, tend incessantly to gather round him at his work as an atmosphere quite unfit for respiration." Further, the report goes on to say: "The air of ill-ventilated mines must be very greatly more impure than the air of ill-ventilated above-ground places, so considerable must be its defect of oxygen, so considerable its excess of carbonic acid, not only must it be insufficient, often almost urgently insufficient, for healthy respiration. And the same air, besides being chemically insufficient for respiration, also carries with it into the miners' lungs more or less irritant material—material which, though the air were ever so well oxygenated, would itself tend to produce bronchitis—namely, soot, grit, and the acid fumes of combustion."

Sir John goes on to discuss the conditions of health experienced in miners: bronchitis, asthma, phthisis, and cardiac disease, with the exception—and a very important exception—of the miners of Northumberland and Durham. It was found that they did not suffer from any diseases special to their employment, or in excess of other workmen. The explanation given of these striking exceptions is that these two northern counties had good ventilation in their mines. Sir John further quotes the good effect of sufficient ventilation in some Welsh mines, where the miners were reported by the manager, by the surgeon, and by some of the men themselves, to be nearly exempt from miners' asthma. Quotations might be made of opinions given by other writers, but these are generally founded on Simon's report, and the point seems to be abundantly proved that, twenty-five years ago at any rate, the air of mines was bad, and the effect on the health of the miners was correspondingly bad.

In the succeeding tables facts of considerable importance are brought out. In the parish of Beath we have a mean death-rate from phthisis for both sexes of 1·33 for 1000 living. For males for

the same years the mortality was 1·01, and for females 1·72. If occupation had any effect in causing an increased mortality in miners, then we would have expected a higher mortality amongst males than females. But the opposite is the case, and this in a population where adult males are almost entirely miners. The general condition of the parish is not at all favourable to a low mortality from phthisis, the soil being stiff clay, as a rule, and very wet, marshy in many places, and liable to be swept by cold winds, there being very little shelter either from trees or hills. The housing is also indifferent, and overcrowding prevails to a considerable extent. Those conditions might be expected to lead to a higher death-rate from phthisis, even without the influence of occupation. When we compare the phthisis death-rate with other places, we find, from Farr's statistics, that in years 1850-54 there was a mean mortality from phthisis of 2·811, in 1855-57 a mortality of 2·683, and in years 1857-63 a mortality of 2·574; and in Scotland, from 1858 to 1861, a mortality of 3 per 1000, for Leith 2 per 1000, and for Glasgow 4 per 1000 living.

It will at once be seen that these rates exceed very much the death-rates from phthisis in an almost purely mining district. Although we have thus a low mortality from phthisis, of course it might be that the effect of occupation might show itself in increased deaths from other causes. A reference to other tables will show that, for the same periods as already given, the mortality from all causes given in the mean was 15·79 per 1000 living, and this, of course, is a tolerably low mortality. Comparing this rate with the rate for all England for twelve periods, we find that the rate of the latter exceeds this by about 4 deaths per 1000. Coming to the last column, we have the mean age at death of miners, and the average for twelve years, we find, is 43·1. In the list of deaths I found that one miner died at the age of 86, one at 74, another at 73, and several at 69; and those men were miners when the conditions of occupation were much more unfavourable than those experienced at the present day.

Deaths in Parish of Beath from Phthisis from year 1876 *to* 1887, *according to Sex. Total Mortality. Mean Age at Death.*

Year.	Deaths per 1,000. Phthisis: Males.	Deaths per 1,000. Phthisis: Females.	Deaths per 1,000. Phthisis: Both Sexes.	Per 1,000 Deaths. All Causes.	Miners. Mean Age. Deaths.
1876	1·213	0·991	1·113	16·6	43·5
1877	1·555	0·999	1·283	18·1	43
1878	0·375	0·461	0·412	17·6	37·3
1879	0·723	0·443	0·597	10·3	47·2
1880	0·349	1·691	0·956	15·1	40·5
1881	1·677	2·031	1·837	16·5	32·8
1882	1·62	1·592	1·592	15·5	53
1883	1·567	2·042	2·042	17·6	39·6
1884	0·000	1·147	1·147	15·4	51·7
1885	0·584	1·113	1·113	14·4	48
1886	1·147	1·698	1·698	14	49·7
1887	1·398	2·272	2·272	18·4	41·1
Mean for 12 years,	1·01	1·72	1·33	15·79	43·1

Average Annual Rate of Mortality to 1,000 *Living from Phthisis in England for Three Periods.*

Years.	Lung Diseases.	Phthisis.	Increase.
1850-54,	2·769	2·811	—
1855-57,	3·103	2·683	0·206
1857-63,	3·809	2·574	0·097

Rate from Phthisis in Scotland.

Years.	Scotland.	Leith.	Glasgow.
1858-61	3	2	4

General Considerations and Conclusions.—From comparison of the state of air in coal mines with that in one-room houses, schools naturally ventilated, and manufactories, it will be admitted, that it is wonderfully good. The problem of mine ventilation is a difficult one, but by the use of fans it has been solved to a certain and large extent. It would not be easy, if possible, to insure that the air of mines would be as pure as the air above ground, as so many causes are co-operating to vitiate mine air—respiration and excretions of men and horses; combustion of powder, oil, and tallow; exudation of gases peculiar to the various minerals met with in mines; and the decomposition of wood. To keep the product of all these in moderation a large and ever-moving volume of air must pass in and out of the mine. The sectional

area of the air shaft would have to be much larger than present uses demand if the impurities were to be reduced to the quantity found in pure air, but the present system might, in my mind, be much improved by attention to some points which have struck me in the present inquiry, and which I now venture to suggest to those concerned.

The miner spends about one-third of each day in the mine, and we may assume that about one-third of his excreta pass into the mine, and there remain as a source of pollution for an indefinite time. Horses are at all times in the mine, and their excreta are constantly polluting the air, and this cannot even partially be avoided. The evil produced by the former might be diminished by the use of some form of earth closet, small coal or coal dust taking the place of earth. The receptacles could be removed daily or weekly, according to circumstances. This proposal may not strike a coal owner or manager as being practicable, but it is very simple and to a certain extent it would diminish the difficulties and the cost of ventilation. As regards pollution by horses, it is not convenient always to have stables in the upcast shaft, but for the sake of the air they should be; for the sake of the horses the stables are better in the downcast, as where the stables are in the upcast pit experience proves that they do not live so long as in the downcast. Wherever the stables are, means should be taken to purify them; impermeable floors which can be washed out with water, lime-washed walls, and careful attention to daily cleaning out of litter, would all help the problem of ventilation.

Natural means should assist artificial; thus, if the mouth of the upcast shaft were bell-shaped, and by a weather-cock arrangement made so as not to face the wind, its aspirating action would assist the fan instead of rather opposing it, as it does with the present system; and in the case of the downcast a sail or brattice might be so arranged as to promote the down current. Further, in the case of the downcast, all source of vitiation should be removed from near its mouth, such as tar, oil, parraffin, etc., and there should be no chance of currents passing from the furnace holes down the shaft.

The Work of the Miner and its Effects.—Twenty years ago air

was very bad in many mines; ventilation in some of them was almost unknown, and the hours were very long. Nowadays, the air is generally good; ventilation is efficiently carried on, and hours of work are short. The miner works hard whilst at his work, but he has short hours and many holidays. In the table of statistics I have shown that phthisis, contrary to general opinion, is not a common disease amongst miners; and my own everyday experience for ten years in a large mining population supports those tables. In fact, I know of no disease peculiar to miners, or any disease in excess existing among miners. I have also consulted many other medical men practising amongst colliers, and their opinion coincides with my own. In conclusion, I have to state, as my belief, that the conditions connected with miners' occupation are as favourable to health as those in the occupation of any other workmen, and this opinion is borne out by the vital statistics quoted.

In Plate V. is a record of temperatures, shewn diagramatically. The thermometers, two in number, were placed—one at the bottom of a downcast shaft, 100 fathoms deep; and the other at the bottom of the upcast, also 100 fathoms deep. The temperatures of the downcast are shewn by black lines, and those of the upcast by red lines.

The points of importance to be noted are the most remarkable uniformity of the temperatures of the air in the upcast shaft, more striking even than those given where the thermometer, 1000 yards from the bottom of the downcast, is compared with one on the surface.

The wet-bulb readings in connection with the readings of this table are not given in the chart, but the air of the upcast is almost invariably saturated.

From a mining engineer's point of view, those readings, I might suppose, are important in reference to the supposed relationship between changing conditions of temperature above ground and the occurrence of explosions below. And my experience, so far as these records go, is that variations of the temperature above ground, whether in the case of a rise or a fall, make no appreciable difference on the temperature 1000 yards from the bottom of the

downcast; and in the case of the upcast, where the air has passed all through the ramifications of the underground workings, there is also no appreciable relationship. As far as atmospheric temperature is concerned, I think, therefore, it is not a factor to be considered as influencing explosions of gases.

As the air of mines in this district is also nearly always saturated, this must add to diminished risks of explosions from gases and coal dust.

This method of investigation, in my mind, offers a wide field, and an important one, and those who have facilities for such work would be rewarded by making careful barometric and theremometric observations on the surface and comparing them with similar observations made below, especially in "fiery" districts.

At some future time, I propose experimenting to ascertain *what distance from the bottom of the downcast* is necessary to give practically an unvarying, or only slightly varying, temperature.

Another probably important subject, upon which we have no information, is the electrical condition of the mine atmosphere in relation to the occurrence of explosions.

DISCUSSION.

The PRESIDENT said he thought they had had something new in this paper, and he hoped it would give them food for reflection and for discussion at next meeting. He noticed that praise was given to the North of England for its ventilation twenty-five years ago. They had one of the Inspectors for that district (Mr Bell) with them that evening, and he would be glad to hear that his district was so far to the front then. Of course, matters were now very different in Scotland from what they were then, and if the advance had been as great in Northumberland and Durham, then he might safely say their system of ventilation must be perfection.

The discussion of the paper was adjourned.

EDISON & SWAN COMPANY'S SAFETY LAMP.

Mr DALGLEISH, a representative of the Company, exhibited and described the Edison and Swan Company's electric safety lamp, a drawing of which is here shown.

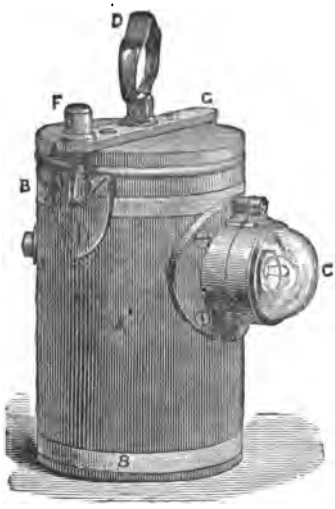


FIG. 1.

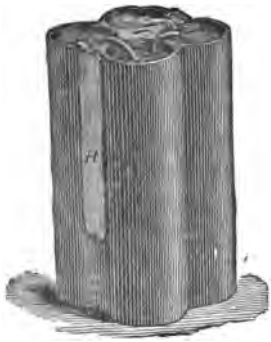


FIG. 2.

FIG. 4.

FIG. 3.

FIG. 5.

The lamp is constructed to give a light of about one candle-power for a period of about ten to fifteen hours, and consists of a storage battery of four cells enclosed in a strong teak box (A) turned out of the solid and strengthened with metal bands (BB); and a small burner mounted on the side of the case, and protected by a strong glass cover (C). The case is fitted with a hinged lid secured by a cross bar fastened with a safety-nut (F), and having a swivel handle (D).

The full size of the lamp is 7 inches by 4¼ inches, and the weight of the whole ready for use is about 7lbs.

The lamp is opened by unscrewing the safety-nut (F) by means

of a special key, and lifting the lid which turns on a hinge at (G). Then by means of the hook (fig. 3) the battery can be withdrawn.

Fig. 1. represents the lamp ready for use.

Fig. 2. The battery withdrawn from the case, consisting of four cells or accumulators joined in series, the terminals being brought down the sides of the battery as shown at H in the form of two contact plates which, when the battery is put into the case, make contact with two corresponding plates inside the case, and so convey the current from the battery to the burner.

Fig. 3. Hook for lifting out the battery.

Fig. 4. Screwdriver used to remove the glass cover when replacing the burner.

Fig. 5. Pipette for filling the battery with acid.

The lamp may also be had with fire-damp indicator attached.

DIRECTIONS FOR USE.

1. The lamp is fitted with a switch for turning the light on and off. Great care must be taken not to allow the lamp to continue in action after the light begins to turn red, as this will injure the battery.

2. To charge the battery with current. The E.M.F. of the charging circuit should be from 9·5 to 10 volts for each battery of four compartments, and the current from ·5 to ·6 ampère.

A. Ascertain the direction of the charging current by attaching a lead wire to each of the two terminal wires, holding them a little apart while immersed in dilute acid in a saucer or similar vessel. Presently one lead wire will turn dark chocolate colour : this will be the wire to be fixed to the side of the battery marked "P."

B. The battery should be kept on the charging current for about nine hours. Under narmal conditions this will be sufficient to fully charge it.

3. When the battery is placed in the case, care should be taken that the lead strips on the side of the battery make contact with the lead stripes inside the case. The lid is to be shut down, and the safety-nut screwed on.

4. The lead strips on the side of the battery and the inside of

the case must be kept clean and well rubbed with black lead. The contacts must on no account be allowed to become coated with peroxide of lead.

5. The battery plates *must* be kept covered with acid. Dilute acid of the right strength may be made by mixing one measure of acid with eight of water.

6. The lamp should be kept in the upright position always.

7. Should the cells become sulphated, they are best brought back to their original condition by charging with a larger current for a time, say ·75 or 1·0 ampère.

8. If acid is spilt in the case, the battery should be withdrawn by means of the hook, and the case rinsed out with clean water.

9. All cells will in future be sent out charged.

NOTE.—The battery may be charged for experimental purposes on a circuit of much higher E.M.F. by putting a resistance or lamp in series with the battery. Lamps for this purpose, to suit any circuit, will be supplied by the company, if required, on receipt of information as to the E.M.F. of the circuit.

LIST OF PRICES.

Lamps and Accessories.

Edison & Swan Company's Safety Lamp, ...	£1	10	0
Edison & Swan Company's Safety Lamp, with Fire-Damp Indicator attached, ...	2	5	0
Battery only, ...	0	9	0
New Set of Grids, for Old G.P. Cells, ...	0	6	6
Glass Covers, each, ...	0	1	0
Burners, each, ...			
Fire-Damp Indicator, ...	0	12	6
Fitting Indicator to Old Case, ...	0	2	6
Key for Unlocking Safety Nut, ...	0	0	6
Hook for Lifting Out Battery, ...	0	0	6
Special Screw-Driver for Glass Covers, ...	0	0	6
Pipette for Filling Cells with acid, ...	0	0	6

The above prices are for delivery at the Company's factory, Ponder's End, Middlesex, Packing charged extra.

Charging frames and table for same with plate-glass top, specially estimated for according to size.

The cost of frames for charging 200 lamps at once, with plate-glass covered table, racks, bench, and large lead-lined tank for

washing batteries, may be taken approximately at about £25. The cost of a special building for containing a plant of this size, built of brick and slated, with brick paved floor, should not exceed £40.

Mr DALGLEISH, in reply to questions, said the fire-damp indicator, which it was proposed to fit on to the lamp, was undergoing modification, the previous form not having been found quite satisfactory. The light could be made to show at an angle to the roof. Seven pounds was the lowest weight they had yet attained to.

Mr BELL asked if the lamps had been in use.

Mr DALGLEISH said they had had about 300 or 400 of the lamps in use in South Wales for over a year, and within the last three weeks they had had an order for about 100 from the Bristol Colliery Coy.

Mr GILCHRIST asked how many electricians were required.

Mr DALGLEISH said one, or rather a man about the place who was shewn how to do the work. He explained further that they were contemplating the construction of a lamp of less weight. Five pounds had been given as the outside limit that would be suitable, and the object was to provide a lamp for firemen and others that could be attached to a belt or carried in the teeth.

The PRESIDENT said a fireman crawling along a working with five lbs. weight in his teeth was not to be envied.

Mr DALGLEISH said he had crawled along a working 3½ feet high with the lamp. The cost of the burners was—when taken in small quantities, 5s; and when taken in large, from 3s 9d to 3s 6d. They were no cheaper than what ordinary 16-candle lamps were. That was really where the cost lay, the expense of charging and renewing the batteries being small.

The PRESIDENT expressed the indebtedness of the Institute to Mr Dalgleish for showing this lamp. He had no doubt a lamp of this sort was likely to be the lamp of the future. He did not know if they had got it yet, but they seemed to be on the road towards it.

Arrangements were made for sending samples of the lamp to various collieries to be tested as soon as the fire-damp indicator was ready.

FIG

FIG. 8.

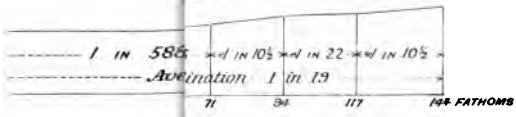
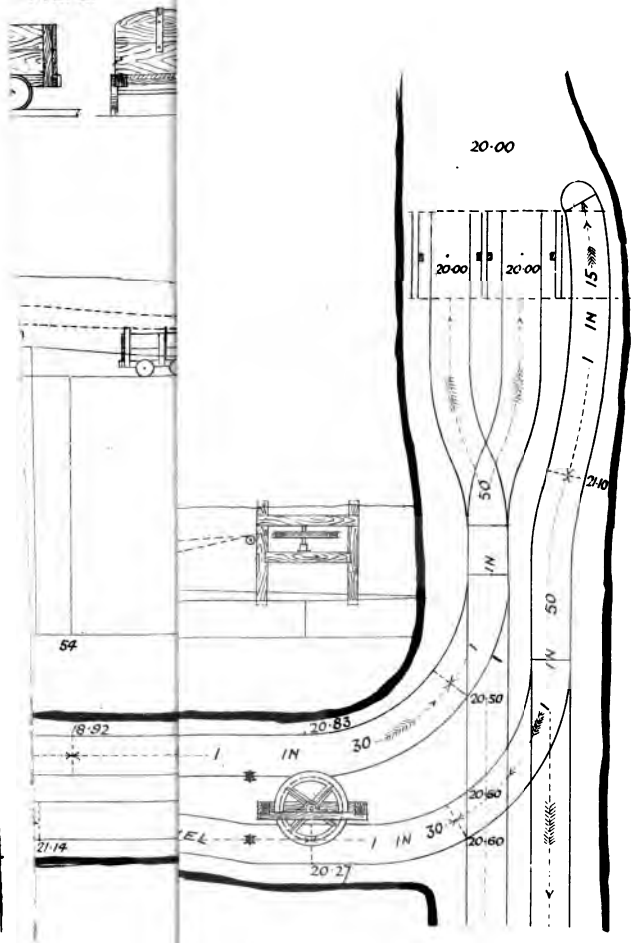

1 IN 58½
1 IN 10½
1 IN 22
1 IN 10½
Average 1 in 19
71
94
117
144 FATHOMS

FIG. 2.


20·00
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IN
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21·10
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1
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54
18·92
20·83
30
1
IN
20·60
21·14
1 IN 30
20·60
20·27

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

22nd November, 1888.

JOHN M. RONALDSON, Esq., President, in the Chair.

The minutes of the last General Meeting were read by the Secretary and confirmed.

The following gentlemen, who had been duly nominated, were elected by ballot as ordinary members :—

ROBERT SNEDDON, Addiewell Works, West Calder.
H. M. CADELL of Grange, F.R.S.E., Bo'ness.
WILLIAM SCOTT, Vogrie Colliery, Gorebridge.
ANDREW PETTIGREW, Bellsdyke Colliery, Airdrie.
ALEX. ADDIE, Bellsdyke Colliery, Airdrie.
JAMES HERON, Auldhouseburn Colliery, Muirkirk.

The following discussions then took place :—

DISCUSSION OF MR DAVID M. MOWAT'S PAPER ON "HAULAGE BY SELF-ACTING ENDLESS CHAINS."

Mr MOWAT drew attention to the following corrections to be made in his paper:—At the top line of p. 156, read "x" for "q"; and near the bottom of p. 157, read "sine" for "tangent."

Mr JAMES S. DIXON said he was very much pleased indeed with the paper, which not only explained practically how this haulage was carried out, but theoretically a great many points in connection with it. It was a system of haulage which he had seen working in considerable perfection some years ago, at Seaton Delaval Colliery, in the North of England. In that case, there was a mine driven from one seam up to another, and the full hutches came down that mine pulling the haulage along a considerable length of the level road at the top, and also from the foot of the mine to the pit bottom. One advantage of the system was the long life of the chains as compared with ropes. Mr Mowat said chains lasted from twelve to eighteen years. That seemed to be an extraordinary length of life. He would like to ask him if, in very long roads, where a load had probably to be taken a mile or a mile and a half, there was any serious objection on account of the great weight of the chain as compared with the short roads, of which examples were given in the paper?

The PRESIDENT—Is there any disadvantage in the chain as compared with ropes?

Mr RALPH MOORE said perhaps they would allow him to state that this was about the smartest paper he had read on this subject. It might have been a little longer with advantage; but, as an example of chain haulage, he had not seen a paper, in the the same space, so admirably illustrated, and the calculations so very neat. Where chains could be adopted, they were very much preferable to ropes in point of life, but there were many cases in which ropes could be, and were adopted, where chains were not so suitable. At the same time, Mr Dixon had, he thought, hit upon a weak point, the excessive length; and perhaps Mr Mowat

would be able to say something on that. He had only to repeat that this was an exceedingly creditable paper, and he should like to see many such before the Institute. (Cheers.)

The PRESIDENT said there was one point that had not been referred to, viz., where the chain could be applied. There were many cases where the roof was so bad that they really could not afford to have a road wide enough for two lines of rails; and, of course, in the case of an ordinary self-acting incline, the road can be single, except at the meeting. That was exceptional, but it was one case where they might safely say it was not practicable to have this system of chain haulage.

Mr MOWAT, in reply, said they had no self-acting roads of any great length, but at Dykehead Colliery there was one which, with a branch, was fully a mile long; and the weight of the chain was never any great obstacle. In a self-acting incline a mile or a mile and a half each hundred fathoms would act for itself, and the only thing would be the size of the chain, which, owing to the increased tension, would be increased. The friction would also be increased, but there would be the same weight of chain on the empties as on the loaded hutches. It would, therefore, not affect the running, and the cost would be the same. As to the President's difficulty, at Garscube, they had in the Long-wall workings two roads, one for the full hutches and another for the empties. Of course, four wheels were required instead of two, and there was extra expense owing to the stations being so much apart.

Mr DIXON said with a very long heavy chain there was another disadvantage in the wear and tear of the hutches. He knew in endless chain haulage, this had been a serious disadvantage.

The PRESIDENT—Do you mean the simple weight of the chain in addition to the road?

Mr DIXON—With a very heavy chain on the top of the hutches, and it is apt to draw them to pieces.

The PRESIDENT—In a long road a greater number of hutches is required.

Mr MOWAT—Yes, but the regularity of delivery makes up for that.

Mr PITCAIRN asked if, after the hutches were all hung on, the brake was used.

Mr MOWAT answered in the affirmative.

Mr JOHN HOGG said he had seen this chain in operation at Braidhurst within the last few days, and it was working very satisfactorily. He also saw another place in the same pit where it might be adopted, and where an ordinary cousie, apparently, would not work, being steep at the bottom and flat at the top. They tried to work it in the ordinary way and failed; and it seemed to be a place where the chain might be adopted beneficially.

The PRESIDENT said in Drumpellier Mr Mowat had an opportunity of comparing the one with the other, and he supposed he would be satisfied if he had a large output to the rise it would have been more satisfactory to use the chain.

Mr MOWAT thought so. The chain was heavy, and he did not think there was any excessive wear on the hutch. The weight of the chain was about 40lbs. to the fathom.

Mr JAMES GILCHRIST said there was another point which had been omitted where it could be planted with advantage, viz., in very steep workings,—where the workings were rising very much there was a difficulty in making a landing for the cousie race, and more especially where the road was flat at the bottom. He knew a case where something like that was to be applied shortly, and where it was the principal reason why they were adopting either the endless rope or endless chain. The gradient at the bottom was nearly level, and at the top it was rising 1 in 4. In a case like that, it might be applied with great advantage.

On the motion of the PRESIDENT, a hearty vote of thanks was given to Mr Mowat for his paper.

DISCUSSION OF DR. T. G. NASMYTH'S PAPER ON "THE AIR OF COAL MINES."

THE PRESIDENT, in opening the discussion on this paper, said the subject was one they had not had before them hitherto. It was a very important one, viz., ventilation from a doctor's point of view. Of course it was in the doctor's line as well as that of the colliery manager; for, while he had to look after the health of the miner and his dependants above ground, he naturally took an interest in the sort of atmosphere he worked in.

Mr RALPH MOORE said he had read this paper with a great deal of interest. Dr. Nasmyth was an example to the medical men about their collieries. There was a hard-working professional man taking up his time looking after those below. It was very desirable, and if it should only be the means of making known to the medical gentlemen about their collieries the use that they might be to their constituents, by not merely administering potions, but by making observations such as Dr Naysmith's, much good would be done. It was an industrious paper. There were two or three things that struck him. The first of these was as regarded those microscopic experiments. It was interesting to see how the ventilation decreased the effects. Another thing was as regarded what they might call the sanitary arrangements. All of them who had been surveyors and had known the difficulty could sympathize with what was said. He had often felt that a great deal could be done, and they (the members of the Institute) were the proper parties to do it. He did not suppose that so much harm was done by the miners at the face, but when they considered that about a third of the persons employed were oncost men (drivers, drawers, people engaged at sidings and about the shafts) he did think that a good deal might be done in the way of avoiding smells and other things of that kind about these places. Dr. Nasmyth suggested earth closets. He had known places where these were adopted. He thought at the present moment at Lesmahagow there was something of that kind. He thought that was worth noticing. The other point he wished to mention was that the conclusion of the whole

matter was that the colliers' life was a more healthy occupation than any other. Dr. Nasmyth even showed that in lung disease the mortality amongst men was 1·01 and amongst females 1·72 in the mining districts, which was very wonderful. It was not quite new, because if they studied the vital statistics of the country they would find that miners were a long-lived set. In mining districts they were a good deal longer-lived than where the employment necessitated their enduring more or less the variations of bad weather, as in outdoor work. He thought there was no doubt that ventilation had progressed along with the other improvements in working coal, and that had something to do with it; but at the present moment he was quite inclined to agree with the writer that a miner's occupation was not an unhealthy one.

The PRESIDENT suggested that the paper would have been very much more useful had it been accompanied by a plan shewing the various parts of the mine in which those specimens of air were taken for analysis, and also shewing the quantities of air passing at or near those points. It would be a most instructive thing to have, and would bring home to many the great necessity for seeing that every working-place in the mine was properly ventilated. Dr. Nasmyth talked of ventilation by diffusion of gases. Now, a great many pinned their faith on ventilation by that method, especially in stoop-and-room workings in non-fiery mines. He thought enough of attention was not paid in non-fiery mines, especially in stoop-and-room workings, to carrying in the air by means of bratticing. It cost more, but where a mine was fiery it was done and nobody thought anything about it. Sometimes the air passing through the mine was very good; but in at the actual face, especially if the workings were anything steep, the atmosphere really was not what it should be. He thought if a few specimens of air were taken for analysis out of these places and compared with air from the air-course in the close proximity, many people would be very much astonished at the difference shewn. He noticed in the newspapers the other day, in connection with the ventilation of one of the churches in Edinburgh, some experiments were made shewing how that in a short time after the congregation assembled the air was really unfit for human

beings. Of course, people did not congregate in a working-place as in a church, but still the same principle, more or less applied there; and he thought a great deal more might be done in many mines to make the ventilation of such places more satisfactory.

Mr J. B. DALZELL said perhaps the suggestion the President made might be carried into effect yet. They might have a diagram in time for the next "Transactions," shewing the position where the air for the analysis was got, and the speed of the current at each point.

Mr HASTIE said he noticed that in the months of September, October, November, December, January, and so on, Dr. Nasmyth took the readings of the thermometer at a point a thousand yards from the pit bottom. He seemed to have stationed the thermometer at the same place, as the variations are nearly equal, shewing a difference of only 2° 5″ in all readings underground. If the thermometer had been stationed at different points during the readings, the difference would have been more. On the surface during these readings the variation is 14°.

Mr DIXON said Dr Nasmyth would take his readings where the temperature would be the temperature of the mine itself. He thought the suggestion of the President was a very valuable one. At the bottom of p. 172, they would notice the analysis of the air gave a percentage less of oxygen. If these trials were made at the air-course and at the face, and there was a considerable discrepancy—a palpable difference—it might do good, because it would at once show the weakness of the position. He thought the paper was a very valuable one indeed, and he did not remember seeing such a paper in any "Transactions," and he thought, as an Institute, they were very much obliged to Dr. Nasmyth for bringing this paper before them. It was a unique subject for Mining Institutes to have before them, and it was one that might be followed up with considerable advantage.

Mr RALPH MOORE said the Commissioners of Mines, he thought, about the year 1860, in a report by Dr. Smith, published a very elaborate series of analyses upon the air in mines, and further back than that, he recollected—he thought fifty years ago —Dr. Allison, of Edinburgh, also published some analyses about it. But he did not think there was anything more complete by

a country practitioner. Dr. Smith's analyses were very valuable and, after all, they would be astonished how little difference there was between good and bad air, so far as analyses went. He believed Dr. Nasmyth would be willing to furnish the information desired by the President, as well as answering any question that might be put, with the view of making his paper more useful.

The PRESIDENT said, in looking over the tables at the foot of p. 181, there were some apparent extraordinary variations between the temperatures above ground and below ground. The temperature was taken at the pit mouth, and again at the pit bottom, in the downcast shaft. He thought it would require some explanation. On January 14, above ground the temperature was 35°, dry bulb; below ground, 54°. On March 19, it was the same above, and only 41° underground. There were such variations as that throughout the table, and it was difficult to understand it unless there was some extraordinary change in the quantity of air going down the shaft, or some source of heat near the bottom, that existed at one time and not at another. It seemed rather difficult to understand how such a state of matters could arise, unless they had some explanation on the subject. He thought the depth of the pit was not given.

Mr JOHNSTONE—Nor whether it is upcast or downcast.

Mr DIXON—The first table is a thousand yards into the workings. As he had said, that was a place where the normal heat of the mine was to be found.

The SECRETARY said it might be well to state that this paper was prepared not with the view of being read before the Mining Institute of Scotland. Probably, had the Doctor had it in view that it was to be submitted to a society such as this, he might have treated it in a manner more directly bearing on mining considerations. He thought that should be taken into account, and he thought also that Dr. Nasmyth would be glad enough to receive suggestions as to the directions in which his experiments might be made more available for the guidance of mining men.

Mr RALPH MOORE thought all the members who had to do with medical men should inform them as to what had been done by Dr. Nasmyth, and impress on them to go and do likewise.

Mr THORNEYCROFT said, with regard to the statistics bearing on the healthiness of the miners' occupation, that there had been an article in the *Nineteenth Century* of April last, which went into the question of the relative healthiness of occupations, and showed that, next to the farmer, the miner's was the most healthy occupation.

The SECRETARY said there must be some good reason why a horse improved more in a pit than on the surface.

The PRESIDENT said he had noticed that for some time. He knew an old horse that had been twenty years in a mine which was fresher than ever the last time he saw it. He thought the temperature had to do with it. They were not exposed to rain and the variations of temperature. That must have a great deal to do with the matter.

The SECRETARY—The same thing applies to workmen underground as compared with quarrymen.

Mr RALPH MOORE said it was wonderful how very little air a man would live on, as was evidenced by the entombed miners in South Wales, who were confined for a number of days in a space five yards wide by ten or fifteen yards long, and came out alive.

The discussion was adjourned.

The following paper on "Longwall working in the Edge Seams, Niddrie Collieries, Mid-Lothian," was then read by Mr Hugh Johnstone :—

LONGWALL WORKING IN THE EDGE SEAMS AT NIDDRIE COLLIERIES, MID-LOTHIAN.

By Hugh Johnstone.

The following short description of the longwall workings in the edge seams at Niddrie Collieries is submitted to the members of the Institute in the hope that it may be of some interest to them, not on account of the mode of working described being strikingly new, but simply as being a successful application of known methods under peculiar conditions.

The Mid-Lothian coal-field forms an irregularly shaped basin or trough, extending for a length of about 17 miles from north-east to south-west, and for a breadth of from 2½ to 9½ miles. With the exception of an area of about twenty square miles in the centre of the basin, which is covered by the true Coal Measures, the whole field belongs to the Carboniferous Limestone series. The strata crop out on the east, south, and west sides of the basin, and dip towards its centre, where they reach an estimated depth of about 500 fathoms. On the east and south sides of the basin, the dip varies from 10 to 30 deg., but on the west side it is generally considerably greater. In the neighbourhood of Niddrie, which is situated near the north-west corner of the basin, it varies from 50 to 90 degrees.

Exclusive of the seams found in the true Coal Measures, which are locally known as the "Flat Coals," on account of their very moderate dip, the Niddrie field contains some twenty-six workable seams of coal, varying in thickness from two to eight feet. The following remarks, however, are confined strictly to two of these seams, the "Great Seam" and the "Stairhead Seam," which have been worked at Niddrie much more extensively than any of the others.

The following section shews the relative position and thickness of these two seams, and the nature of the strata immediately over and underlying them :—

				Ft.	In.
	Coal, foul, ...			0	10
	Coal, free, ...			1	7
	Blaes, ...			0	9
	Sandstone, ...			11	0
	Fakey Fireclay, ...			3	0
	Sandstone, ...			9	0
	Coal, free, ...			1	4
	Dark Fakes, ...	0	9 to 2	2	6
	Head Coal, ...	0	6		
	Cannel (No. 1), ...	2	2		
	Ironstone (Blackband), ...	0	5		
GREAT SEAM.	Pelt (inferior ironstone), ...	0	3	8	1
	Coal, free, ...	1	6		
	Daugh,...	0	3		
	Bottom Coal, ...	3	0		
	Fireclay, ...			0	9
	Sandstone, beddy, with fakey plies, ...			30	0
	Dark Fakes, ...	0	0 to 1	6	
	Blaes, ...	0	0 to 0	6	
	Coal, free, ...	1	6		
	Cannel (No. 3), ...	2	3		
STAIRHEAD SEAM.	Ironstone (Blackband), ...	0	6	6	1
	Pelt (inferior ironstone), ...	0	4		
	Coal, free, ...	1	6		
	Hard Fireclay, ...	0	0 to 0	6	
	Sandstone, ...				

The bottom coal of the Great seam is not generally worked; its quality is inferior, and any attempt to work it has usually led to a loss of cannel coal.

Owing probably to their outcrops being so easily discovered, and to the natural facilities for drainage by means of day levels brought up from the sea, these Edge Seams were amongst the earliest worked in Scotland. The day levels were carried inland, in some cases, for several miles; and cross-cut mines were driven to the rise and to the dip, draining the various seams to the sea level.

The mode of working the coal, practised by the "old men," was a form of "Stoop and Room," or more properly that known in Scotland as "Room and Rance." Rooms, generally about 8 feet wide were driven level course; the stoops or rances, which

were from 3 feet to 12 feet thick, were only pierced when necessary for purposes of ventilation, and were invariably left in.

As greater depths were reached, improved methods of draining, winding, and hauling were introduced; the thickness of the stoops was gradually increased to from 30 to 40 feet, and their subsequent removal effected.

Experience has shewn that, down to a vertical depth of about 120 fathoms, with ordinary care and attention, the working and stooping of these edge seams offer little practical difficulty; but as the depth extends beyond this, the difficulties rapidly increase, and the roof weight becomes almost unmanageable. Even in the first or forward working, the roads can only be kept open at enormous expense. The floor of the roads rises, the roof and pavement of the seam come together, the stoops become more or less crushed, and the weight of the loosened coal coming wholly upon the timber necessitates frequent repair and renewal, in order to prevent falls and consequent stoppages. The ordinary expedient of decreasing the percentage of coal taken out in the first working appears to have little or no effect. A single road driven in the solid coal, fifty fathoms below the workings, is nearly as much affected by the weight as the ordinary working places, the roof constantly bursting out between the gears, and the props requiring frequent renewal. Under the same conditions as to roof and pavement, rooms driven 10 feet wide, with the dross and dirt stowed under the rails, leaving a road 6 feet high, are more easily maintained than others driven 6 feet wide and left without stowage.

In the Edge Seams, the extent to which the percentage of coal taken out in the first working can be reduced, is strictly limited, because, at a greater thickness than about 40 feet, the stoops become unmanageable. The difficulty and expense of removing them are enormously increased, and the loss of coal is considerable.

These evils affected the cost of production to such an extent that, some four years ago, it became evident to the writer that we were rapidly reaching the point at which working by Stoop and Room in any form would become altogether impracticable, and

that the adoption of some description of Longwall was therefore essential.

The chief difficulty which presented itself at the outset was the want of sufficient and proper stowage. Owing to the dip being considerably greater than the angle of repose for loose materials, it was essential that the goaf should be stowed full; and neither of the two seams contained anything like sufficient rubbish for this purpose.

After full consideration of the special circumstances, the plans hereinafter described were adopted and successfully carried out. Both seams have been worked by these methods, but to prevent confusion, the Great Seam working only will be described.

The coal is generally worked in lifts or "fetches" of from 60 to 80 fms. in depth; and is divided into panels of about 200 fms. in length. In each panel, and preferably near its centre, a brake incline is formed, by means of which the coal is lowered from any intermediate roads to the bottom level, along which it is conveyed to the winding incline or shaft, experience having shewn that a much greater output can be raised by this method than by "hanging on" the tubs on the Winding Incline at each of the intermediate levels.

Following out the practice which had obtained in the Stoop and Room workings for a number of years, all the main roads, brake inclines, &c., were formed in the Stairhead seam, partly to save leaving in Great Seam coal to protect these roads, and partly on account of the superior roof and pavement of the former seam.

In the *inclined* seams, where the angle of dip did not exceed 70°, it was determined to work straight to the rise; but in the *vertical* measures this was manifestly impracticable, and it was necessary to adopt a somewhat different method of working. Each of these methods will be described in turn.

I.—LONGWALL WORKING IN INCLINED SEAMS, DIP NOT EXCEEDING 70°.

The general nature of the working, where the dip does not exceed 70°, is shewn in Fig. 1, which is an elevation, or vertical projection of the working, with the overlying strata removed.

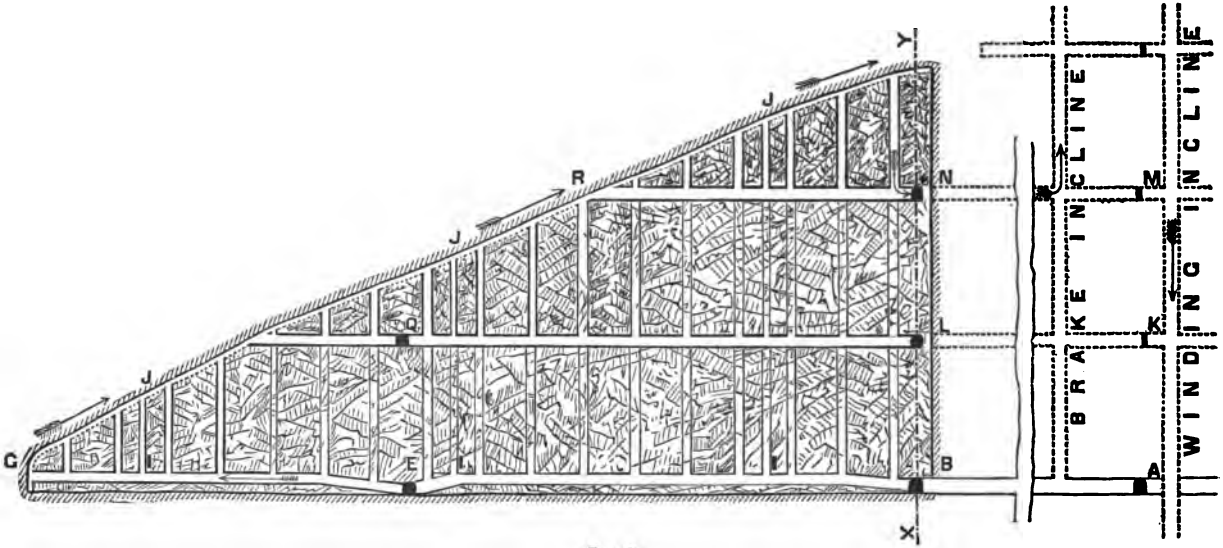


FIG. 1.

Elevation.

Roads in use or course of extension shewn thus—	═══
Do. cut off, ... ,, ,,	═══
Direction of Air Current, .. ,, ,,	An arrow.

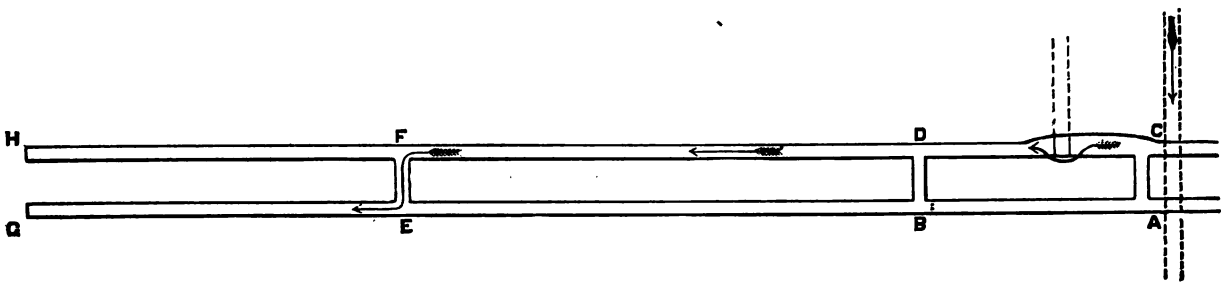


FIG. 2.
Plan at Bottom Levels.

Close levels (A.B. C.D., Figs. 1 and 2) are driven in both seams from the winding incline at the depth fixed upon as the bottom of the lift or "fetch;" and when a sufficient distance has been reached to insure the safety of this incline, they are connected by a cross-cut mine (B.D. Figs. 2 and 3), and the longwall working is commenced. A level (B.E.G., Figs. 1 and 2) is set away, usually 8 yards wide, having 6 feet of stowage under the rails. The rise side is pillared continuously with wood, the pillars being 3ft. thick, built checker-fashion, the open spaces being filled with dross.

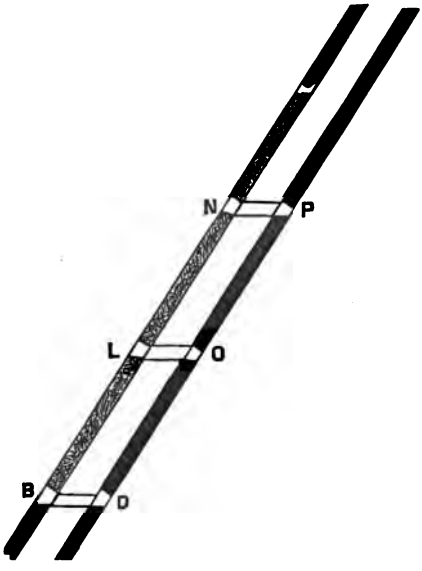


FIG. 3.—Transverse Section on line X Y. *(See Fig. 1.)*

"Spouts" or shoots are branched off, straight to the rise, at intervals of 12 to 16 yards between centres; they are from 3 to 4 feet wide, built and causeyed with the ironstone and pelt. The goaf is stowed with the daugh, dross, rough coal, and any ironstone not required for buildings.

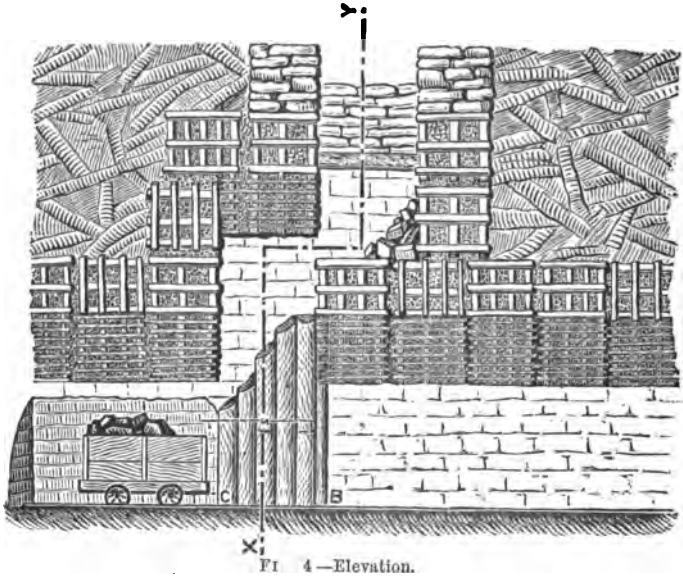
For the convenience of the miners, the walls are arranged so that each has a long rise and a short dip side. The cannel is dropped down the spout, at the bottom of which it is filled into a tub by the drawer.

At intervals of about 70 yards, travelling roads (I.J., Fig. 1) are formed for the purpose of affording convenient access to the working face at different points. These are built similarly to the spouts, and are furnished with ladders.

While the longwall working is progressing, roads (K.L., M.N., Fig. 1) are driven in the Stairhead seam at intervals of about 40 yards, and cross-cut mines (O.L., P.N., Figs. 1 and 2) are driven therefrom to the Great seam, so as to strike this seam before the longwall heading reaches their level. From these mines, intermediate levels (L.Q., N.R. Fig. 1) are carried across the working faces as they come up, cutting off the spouts. The rails for these intermediate levels are laid upon the stowage, and the rise side of road is pillared with wood as in the levels.

The close level in Stairhead seam (D.H., Fig. 2) is carried on in advance of the longwall level in Great Seam, and from it cross-cuts (F.E., Fig. 2) are driven connecting the two seams at intervals of 60 to 80 fathoms for the purpose of cutting off the outbye portion of Great Seam level as soon as the spouts on it have been cut off by the intermediate level above. The same system is followed with the upper levels, the object being to shorten the life of the roads in the Great seam, and to keep the horses or engine haulage as close to the working face as possible.

The method of building the levels and spouts is shewn more in detail in Figs. 4, 5, and 6. The stowage on dip side of level tends to prevent the roof breaking and bursting out in the road. Where the seam yields water, drainage is provided for by placing the larger blocks of ironstone and pelt at the bottom of the stowage. The head coal is usually taken down in the level, as it is considerably crushed by the roof weight, and when it bursts out it is almost impossible to secure it again. The roof is supported by ordinary half-round bars (D., Fig. 5) 8in. by 4in., placed 4 feet apart between centres, and carried by a 5in. prop at each end. In some cases a piece of pillar-wood (E., Fig 5) is laid longitudinally among the stowage, and the lower end of the crown is driven down between it and the roof, the upper end being carried by a prop. This is found to be sufficient to steady the roof until it has come to rest upon the pillars and stowage.



FI 4 —Elevation.

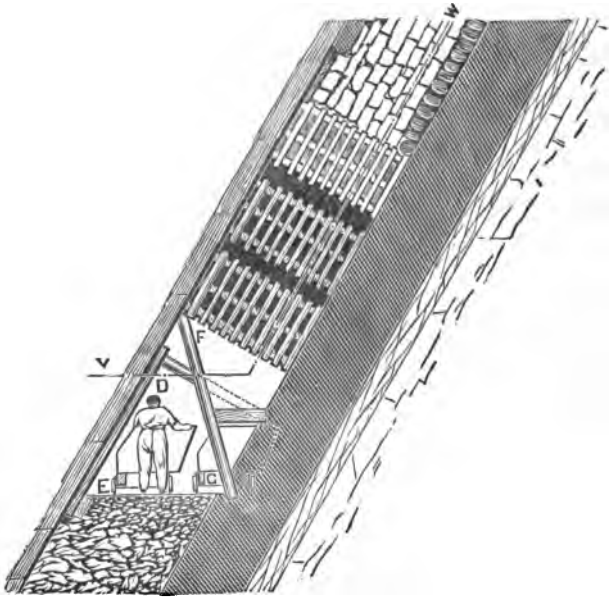


FIG. 5.—Transverse Section on line X Y. (*See Fig.* 4.)

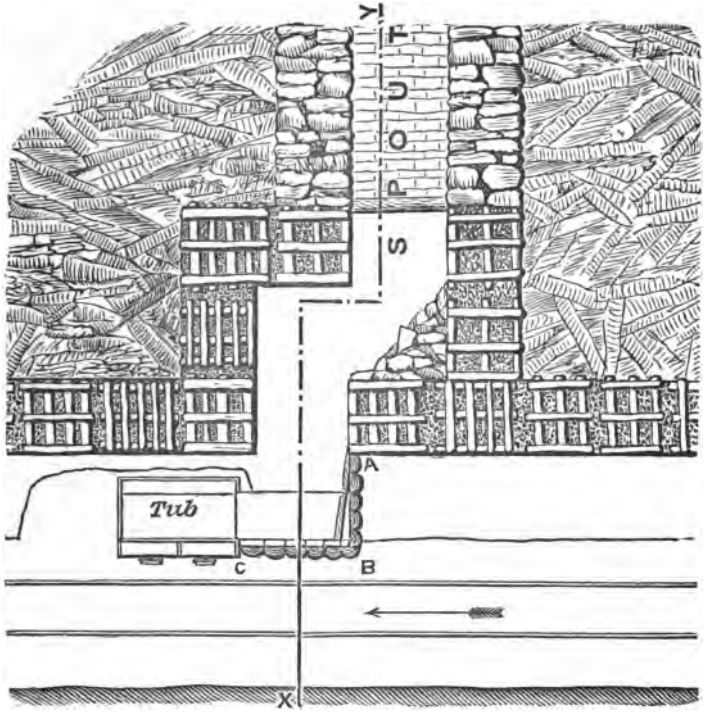


FIG. 6.—Section on line V W. *(See Fig. 5.)*

The pillaring consists of split railway sleepers, slab-wood, broken props, or any description of wood which can be obtained cheaply. It is cut into 3ft. lengths, and, for convenience in building, should be slabbed on two sides. The mode of building is as follows:—A temporary scaffold is formed of 1in. bratticing deals about 4 feet in length, carried by two props set at a little above a right angle to the plane of stratification, and slightly "needled" into roof and pavement. Upon this scaffold the pillar is built in alternate courses of header and stretcher, commencing at the pavement, and continuing up to the roof, where the last course is driven in tightly. Each pillar is "hearted" with dross and dirt, experience having shewn that a pillar of this nature affords a better support to the roof, and is less liable to cause it to burst out in the roadway than one built solidly with timber. As

soon as the roof weight is seen coming upon the scaffolding trees, they are knocked out, and the scaffold taken down, the pressure upon the pillar being then amply sufficient to hold it in position. Many hundreds of fathoms of these pillars have been put in after this fashion, and they have never been known to slip.

As soon as a section of a level (*e g*, L Q, Fig. 1) has been cut off, the pillaring is taken out in the corresponding section (B E, Fig. 1) of the level underneath. The wood so drawn is used a second time, and, when mixed with a little fresh wood, even a third time.

The distance between the levels is determined chiefly by the inclination of the seam and the condition of the packwalls of the spouts. As the inclination increases, the coal falls down the spouts with greater velocity, and the breakage consequently becomes more serious. The ironstone with which the spouts are built varies considerably in its nature—in some places forming very indifferent building material—and when the buildings begin to give way, the expense of repair is very considerable. It therefore becomes simply a question of arithmetic at what point the reduced value of the output, together with the cost of upkeep of spouts, will warrant the outlay for a new cross-cut mine and intermediate level.

The foot of the spout is shown in detail in Figs. 4, 5 and 6. The shield or "battery" (F, G, Fig. 5, and A, B, C, Figs. 4 and 6), is formed for the purpose of protecting drawers and others while passing on the level. It will be observed that the "battery" closes the spout on the *outbye* side. Experience has shown that, when it is so arranged, the air current is much more easily led in to the face of the level, and is less dependent upon the screens, which, it is needless to point out, it is exceedingly difficult to maintain in perfect condition.

In building the side-walls of the spouts, care must be taken that the courses are parallel to the plane of stratification, that the stones are, as far as possible, laid on their natural beds, and that the buildings are well tied together with headers; as it is manifest that a slipped building here is a much more serious matter than in a flat seam. The pavement of the shoot is causewayed with blocks of ironstone set on edge, partly in order to

retard the velocity of the falling cannel, and partly to prevent the heaving and gradual ripping of the ground coal. It was found to be advantageous to bank up the causeway slightly with dross at the sides of the spout, so as to form a rough invert. This tends to keep the causeway in place, and also materially strengthens the buildings.

The length of the walls is determined by the quantity of ironstone and pelt available for building the spouts, and by the output required. Where the length is 12 yards, as in Fig. 1., a miner and a drawer are employed in each wall; when the length is 16 yards, there are usually two miners at the face and a drawer on the level.

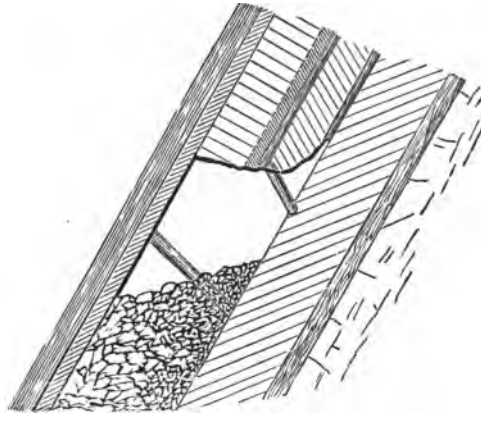


FIG. 7.—Section of working.

	Ft.	In.	
Dark Fakes, ...			
Head Coal, ...	0	6	
Cannel, ...	2	2	4ft. 7in.
Ironstone, ...	0	5	
Pelt, ...	0	3	
Rough Coal, ..	1	6	
Daugh, ...	0	3	
Bottom Coal, ...	3	0	
Fireclay, ...	0	9	
Sandstone, ...			

The coal is easily holed and brought down, and the working gives very little trouble when the faces are kept in line, and not pushed forward too rapidly. Very few props are used at the working face, but the coal is kept closely gibbed, the distance between the gibs being seldom more than 3 to 4 feet. The

parting between the head coal and the cannel being generally rough, it was at first difficult to convince the miners of the necessity for this; but a little experience shewed them that, although the overhanging coal might not appear to be dangerous, the increased freedom with which they could move about in their places more than repaid the time and trouble taken in setting up the gibs.

II.—Longwall Working in Vertical Measures.

In the south-western portion of the leasehold, the seams tilt up until they stand vertically. It was evident that, under these circumstances, the mode of working described was impracticable, as the dropping of the cannel from a comparatively limited height would break it up so much as to render it unmarketable. The plan shewn in Fig. 8. was therefore adopted. The brake incline and haulage roads are made in the Stairhead seam as before. Close levels are branched off this incline at intervals of 56 feet between centres; and from each level a cross-cut mine is driven to the Great seam. The longwall working is commenced on the bottom level A.B. Six feet of stowage is kept below the rails, and the rise side of road is pillared continuously, as already described. The clear height of road is 5ft. 6in. The rise side of working face is kept trailing, so as to form an angle of about 45° with the road.

As soon as this level has been opened up sufficiently to let the rise side reach the level of crosscut mine (C), roads from this mine are laid on the top of the stowage, their rise sides being pillared in the same manner, and the working is extended upwards to crosscut (D), and so on to the top of the brake incline.

The ground coal generally stands well enough in the roads without timber. The roof, which here forms one side of the roadway, is supported where necessary with half-round crowns, 8ft. by 8in. by 4in., placed 4ft. apart; the upper ends of crowns being built into the pillaring, and their lower ends buried in the stowage.

As already stated, the brake inclines are usually about 200 fms. apart, and from each the coal is worked for a distance of 100

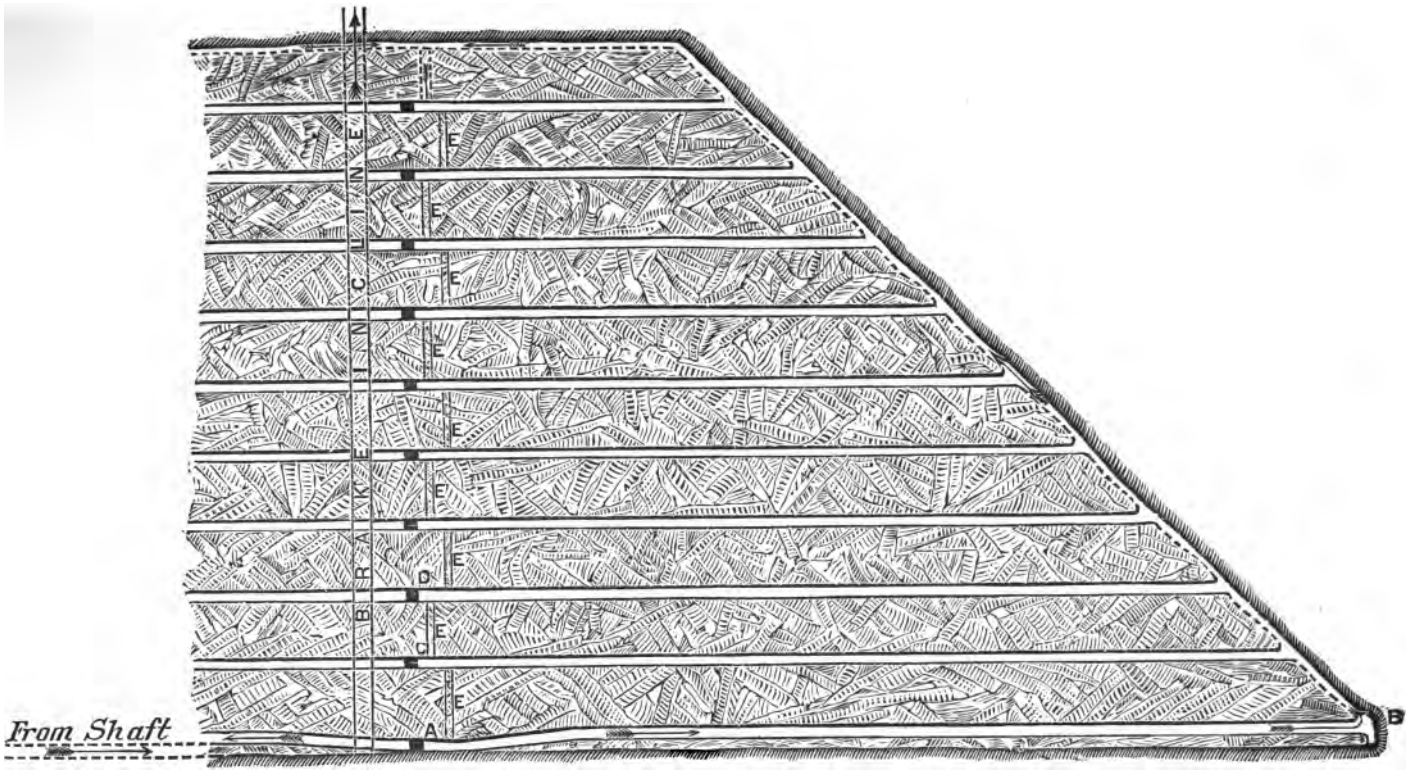


FIG. 8.

fms. on each side. As soon as a road reaches the boundary of the panel, and is thereby cut off, the pillaring is drawn from the road underneath, and used again as already described.

Communication between the different levels is obtained by means of travelling roads (E.E., Fig. 8.) formed in the Stairhead seam and fitted with ladders.

The longwall working first described was commenced over three years ago; that in the vertical measures twelve months later. Experience has amply justified the new departure. The system has been gradually adopted throughout the whole colliery as opportunity offered, and the Stoop-and-Room method has now been almost wholly superseded by it. To one unaccustomed to edge seam mining, it may appear to be a somewhat dangerous method of working, but experience has shown that this is not the case; and, while under the old system, it was frequently difficult to get a sufficient number of stoopers, there is now no difficulty in obtaining men for the longwall working.

Longwall working in edge seams, similar to the method first described, but varying in detail to suit the different nature and inclination of the seams, has been practised for a considerable time at Penicuik, Loanhead, and Rosslyn—to the managers of which collieries the writer was indebted for permission to examine their workings, and for many hints which were of great practical value to him when introducing the system at Niddrie.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW,

27th December, 1888.

JOHN M. RONALDSON, Esq., President, in the Chair.

The minutes of the last General Meeting were read by the Secretary and confirmed.

The following were elected by ballot as ordinary members :—

JOHN CAMPBELL, Darngavil Colliery, Airdrie.
WM. KENNEDY, Whiteside Lane Cottage, Bathgate.
ROBERT W. DRON, Earnock Colliery, Hamilton.
JOHN P. HAMILTON, Umaria Coal Estate, Latni, C.P., India.
EDWARD M'CANN, Westpans, Musselburgh.
JOHN MARSHALL, Auchinharvie Colliery, Stevenston.

The following discussions then took place :—

DISCUSSION OF DR T. G. NASMYTH'S PAPER ON "THE AIR OF COAL MINES."

Dr. NASMYTH communicated as follows :—

I take the opportunity given me by the proof sheets of remarks made on my paper on the "Air of Coal Mines" to reply to some remarks made in the discussion.

In the first place, I have to thank the members of the Association who discussed my paper for their very considerate and courteous criticisms. The paper was freely open to their severe criticism, as it was written by one who of course is not capable of treating such subjects as ventilation of mines in a manner worthy of the Mining Institute ; and further, the paper treats the whole subject from a medical point of view.

As regards the suggestion of a plan to accompany the paper: as the examinations were made in five different mines, there would have been difficulty, and perhaps objections, in getting five plans. I mention usually where the samples were collected. Measurements of the air at the places where the samples were taken would have been a valuable addition, but I found the apparatus I had to carry quite enough, and sometimes more than enough. Thermometers, bellows, bottles, and other apparatus, were very troublesome things in a coal mine. I at once admit, however, the full value of the suggestion.

Regarding the thermometer readings: the reason why one thermometer was placed on the surface and the other 1000 yards in, was because I wished to compare the temperature above-ground with as near as possible what I considered the mean temperature of the mine.

As regards the temperature referred to by the President at page 181: the mine was 50 fathoms deep, and the thermometer in this case was at the bottom of downcast. I wished to ascertain if there was any relationship between surface temperature and the temperature 100 yards down, and if there was any fixed or nearly fixed relationship. In January of 1888 the temperature above was very high for that month, and on 14th January there was a difference between above and below of 19°. On 19th March there was considerable frost, and the difference was 22°. Not

very much variation after all, as the bottom temperature was lowered by the severe fall of temperature on the surface. Over the whole series of records, however, there is no uniformity, and I was disappointed with the results.

In the chart given at the end of the paper there is shown a most remarkable uniformity of records in the upcast air of a 100 fathoms pit—a straight line representing for many days the temperatures.

As suggested by several members, I hope my small effort will lead to more important work in this wide field. The smallness of my contribution must be ascribed to want of time and opportunity, what I did being done under pressure, with much labour, and by utilising time which might have been spent with ample excuse in taking rest, amidst the hardships of an extensive colliery practice.

Mr HUGH JOHNSTONE said Dr Nasmyth might be asked if the pits from which he took the specimens of the air passed through more than one seam. There were such changes in the composition of the downcast air as given in the tables, as suggested to his mind whether there might not be abandoned seams in the shaft giving off carbonic acid gas.

Mr THORNEYCROFT, referring to poisonous gases mentioned in the paper, said little notice was taken of carbonic oxide. Carbonic acid by itself was not poisonous, although it was seriously dangerous in large quantities, causing death from want of oxygen, but if mixed with a small quantity of carbonic oxide the mixture becomes highly dangerous, and will kill any human being or animal. A dog which was compelled to breathe a mixture containing ½ per cent. of carbonic oxide and 4½ per cent. of carbonic acid died in twenty-five minutes, whereas a dog revived which had been kept for three-quarters of an hour in an atmosphere containing 38 per cent. of pure carbonic acid. He had the report on the Crarae Quarry accident, in which Colonel Ford gave the figures of the amount of carbonic oxide and carbonic acid given off from the fumes of gunpowder, and he gave the former at 27 per cent. and the latter at 3 per cent. of the total. It would be interesting to know if Dr Nasmyth had ever estimated the actual quantity of carbonic oxide

in any of the cases experimented on by him. With regard to the microbes spoken of by him, it was admitted that the return air in colliery workings was more detrimental to timber than fresh air, and it was a question whether it was the microbes settled on the timber and attacked it, and whether the white growths they were all familiar with had any connection with, or were the same forms of life as the microbes. If that was the effect, how great was the value of creosote on timber in killing those microbes.

The discussion was adjourned.

DISCUSSION OF MR HUGH JOHNSTONE'S PAPER ON "LONGWALL WORKING IN THE EDGE SEAMS AT NIDDRIE COLLIERIES."

The PRESIDENT said he had seen in several ironstone pits in the western district, workings almost exactly the same as those described in Mr Johnstone's paper. There was one in the neighbourhood of Kilsyth, and in Ayrshire there was an ironstone pit worked in this way, only, the inclination was not so steep. He did not know whether the system came from the east or the west.

Mr R. T. MOORE said he had read Mr Johnstone's paper with great interest, and had to congratulate him on the exceedingly clear way in which he had described the working of the steep seams. There was no doubt, in working those seams, they entered into entirely different conditions from those connected with flat workings. The slipping of the pillars, in the case described in the paper, of a solid place being driven 100 yards below the workings, seemed very remarkable. It must to some extent have been affected by the quality of the roof and pavement. He did not know if there had been any systematic attempt to work these seams by the stoop and room method, leaving large pillars from the very outset. This method was very ingenious, and seemed very well adapted for overcoming the difficulties of the workings.

He perhaps felt more interest in the paper from having at the end of 1884 attended a meeting of the Niddrie Coy., and advised the Chairman to work the gas coal at Niddrie by the long-wall method, in the same way as the ironstone was then being worked at the Shotts Coy.'s mines at Penicuik. The Chairman at that time said that he did not see his way to go into that style of working, and he (Mr Moore) wrote him a report with plans shewing a style of working suitable for the gas coal, and he was glad to see it had now been carried out. At Penicuik there was a seam of coal three or four feet below the ironstone workings, and spouts were driven in it in advance of the face. The ironstone was trundled down these spouts, which were in an entirely different seam. After the spout had gone 40 fathoms, it widened so much at the foot that the roof began to fall, and the stone and ironstone got mixed, and they had to stop. That formed very much the limit to which they could go. Instead of driving a level in the ironstone, as was done in the coal at Niddrie, they were in the habit of driving a cross-cut to serve each pair of spouts from the level in the seam below, and seemed to think the advantage of dispensing with the large wooden pillars on the rise side of the levels more than counterbalanced the cost of driving those cross-cuts. This system had been carried out for several years at Loanhead, and he believed in America there were similar workings where spouts were made in those highly inclined seams, and the coal dropped down them. It was the best system of working those steep workings, which were never so economically worked as the flat seams. There was very great difficulty in working those edge seams in any way. He could only say he was very much pleased with the paper, and that he had read it with very great interest.

Mr JAMES HASTIE said this was a very interesting paper. This was a colliery that had changed its system of working as, in the year 1880, when the members of the Institute had an opportunity of visiting it, it was worked stoop and room; and, if he minded right, he thought he heard the Chairman of the Company say for the working of edge seams he was not prepared to say which was the best system. He thought he also heard one of the men in the management say distinctly, as regarded

the Great seam, it was impracticable to work it long wall. There was then some talk of change as seemingly stoop and room was not doing very well. Four years after they had changed it, and now, after four years' experience, it was apparently being carried on successfully. It was a very complete plan, and Mr Johnstone had explained it very clearly. The only other thing was if it would pay them now.

Mr JAMES S. DIXON said he had not had time to study the paper since it was printed as he would have liked to have done, but he had had great pleasure in hearing Mr Johnstone reading it. He agreed with him that, when they got below 100 fathoms deep, the circumstances altered entirely. Down to that, they could use great liberty, and not much damage would ensue, but below that the weight became so great that it was very difficult to keep a place open. He knew an instance in a shale field where the dip and rise was not so steep,—about 33 degrees,—and where a level driven about 25 yards in the solid to the width of 8 or 9 feet could not be kept open. That was at a vertical depth of 170 fathoms from the surface. Even props 12 inches in diameter were bent and broken after being in a single night. In these circumstances he agreed that long-wall was about the only method, and in the instance he referred to long-wall had been adopted. As to the spouts, the difficulty was to keep them open. When they got to any great length,—probably from 50 to 60 yards,—they began to close, and there was very great difficulty in re-opening them, or in taking out the wooden pillars, which got squeezed between roof and pavement. The workings, as described by Mr Johnstone, were very similar to those in a metalliferous mine in which the rubbish in a vertical working gets so compacted, being squeezed between the walls of the lode, that it becomes almost solid,—so much so, that they could walk with perfect safety under it without timber. Of course they were built with hard material. Referring to plan, figure 8, he would like to ask Mr Johnstone how the material was got down the faces, and whether it would not have been better to have had them on the zig-zag principle, so as to prevent the falling material from injuring the men in the wall further down. He certainly agreed with Mr Johnstone that it was the proper way to work the seam

in the circumstances, and he thought the working at Niddrie had been successful to the extent that the great difficulty previously was to get a sufficient quantity of gas coal; now, they had got so much they did not know what to do with it.

The PRESIDENT said, with reference to the great pressure at great depths, he had noticed in flat seams in Ayrshire in a pit over 200 fathoms deep, large trees as thick as a man's body, which they put in at the pit bottom when opening up the shaft, and which had got broken in a short time and had to be renewed. It was now settled, but he imagined that surface pressure had nothing to do with it. It must have been some swelling of the strata, like lime shells when watered, that caused the pressure in such a case.

Mr MOORE said it must have been, because he understood it was quite possible to drive solid places in the Stairhead seam below it.

The PRESIDENT—It must show that there is something peculiar in the local strata.

Mr DIXON said in the case he referred to there was no difficulty down to about 100 fathoms, but at greater depths there was the difference he had mentioned.

Mr MOWAT asked if the shoots were kept full of coals in order to prevent breakage, and if the working of the one seam affected the other the same as if the workings were overhead.

Mr JOHNSTONE, in replying to the discussion, said, of course it would be understood that in his paper he made absolutely no claim to originality. It had been pointed out that the system of working shewn for the inclined seams had been carried on for ten years. As a matter of fact, a somewhat similar system was carried on at Niddrie about thirty years ago by Sir John Don Wauchhope and given up, the principal reason being that the brushing had to be taken almost entirely out of the roof and pavement. The roof and pavement were hard sandstone, very expensive to work, and Sir John found he could work more cheaply by stoop-and room than longwall. At Penicuik and Gilshochill the conditions were different, inasmuch as the seams were different. As to the slaking action of the air upon the roof and pavement, he did not think that that could affect their

strength or stability to any great extent, for this reason,—if the air had any action whatever on the roof and pavement, it would necessarily have that action altogether irrespective of the depth. With regard to the method adopted in the vertical measures, he claimed no originality for it either, as it was practically a method that had been followed for centuries in metalliferous mining, and was simply the outcome of their peculiar circumstances. In reply to Mr Dixon's question as to how the coal was got down the face, and prevented from passing the road head and possibly injuring some person in the wall below, the faces did not form an unbroken line as was shewn in Fig. 8, but had a slight break at each road head. The details could hardly be shewn correctly in a small scale drawing. As the roads struck the face at an angle of about 45°, the pillaring never could be quite close to the face. It was usually 10 or 12 feet back, while the roadway would be laid up to within 4 or 5 feet of the coal; a bench was thus formed at each road head, which prevented the coal from rolling further down. The face was kept at an angle slightly greater than the angle of repose for loose materials, in order that the gas coal might roll down from the rise side. Of course, members would understand that the wall was entirely on the rise side, and that each miner worked only above the level of his road. With regard to Mr Mowat's question, they did not fill the spouts with coal, because it would lock, and it would be impossible to liberate it. With regard to Mr Moore's remarks, of course he got charge of an old colliery, and it was very difficult to remodel it all at once.

Mr MOORE said what he referred to was the smallness of the pillars.

Mr JOHNSTONE said he had pointed out one serious difficulty in the way of making them very large. They could make them as long as they chose, but when taking out a stoop of more than 40 feet in thickness, they would see the difficulty of keeping the men up to the face. He had tried, and had decreased the quantity of coal taken out in the first working to 13 per cent., which he thought would compare favourably with the most scientific of the flat workings. As a matter of experience, the roads were as difficult to keep under these conditions as when the percentage of coal taken out in the first working was double

this. Something had been said with reference to the cost. Of course the members would understand it was not for him to go into that, but the fact that this system had been adopted throughout the whole colliery seemed to answer Mr Hastie's question more conclusively than anything he could say. If the system had not paid, it would not have been extended. Mr Dixon had referred to the enormous crush on some of the roads in highly inclined seams. He could support him in that, and might mention one instance. Before the longwall method was adopted, he had seen roads left newly timbered with 8-inch diameter wood, and gone back forty-eight hours afterwards, and been unable to go in on his hands and knees. Every tree was broken. As to whether the working of the upper seam affected the lower one, as in flat workings, it appeared to act very similarly. He might mention one peculiarity of edge seam working. In stooping out the Great seam over the top of the Stairhead levels, they found that the timber in these levels was frequently broken immediately in advance of the face of the stooping; but behind the line of the faces the rock between the two seams appeared to rise up, and it was a common experience to find the props which had been driven hard up in the Stairhead level falling out into the roadway.

Mr DIXON said there was one thing, as they saw on p. 205, the strata between the two seams were very good and formed a capital roof for the Stairhead seam, therefore the levels might stand better.

Mr MOORE said, in the Stairhead seam the driving of levels seemed to depend on the quality of the roof.

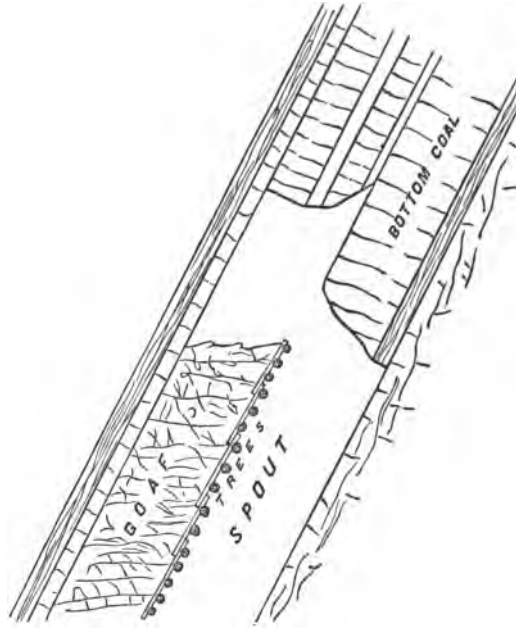
Mr JOHNSTONE—Exactly.

Mr DIXON asked what the depth was.

Mr JOHNSTONE—240 fathoms vertical.

Mr GEORGE THOMSON communicated as follows:—I have read Mr Johnstone's paper on longwall workings in the edge seams at Niddrie with great pleasure. He says, and says truly, that the chief difficulty which presents itself at the outset of longwall workings in edge seams is the want of proper stowage. At Roslin Colliery we adopted the same method as Mr Johnstone has done at Niddrie. This was in the year 1878, but we found

it very expensive for wood, and keeping the spouts in repair. After due consideration we changed our plan, and I see no reason why the same method should not be adopted at Niddrie to advantage. See *Fig. 7.*—section of working.—The pavement consists of a seam of coal 3 ft., with 9 in. of fireclay, plenty of height for a spout. This bottom coal, as I see from the paper, is not worked. The spout should be cut or brushed three feet wide in the coal and fireclay, leaving the sandstone for a pavement, covering the spouts on the top of the bottom coal with light trees, 6 ft. long, 3 in. diameter, a tree every 18 in., and slabs or old wood on the top of the trees, and stowed full with rubbish from the face. (See the accompanying section.) By this method



we ran our spouts between 40 and 50 yards, whereas in building them it was a difficult matter to exceed 30 yards, and at that distance the expense was considerable for repairing, and the work dangerous to perform.

The discussion was adjourned.

The following paper by Mr David Cowan, M. Inst., C.E., manager for Carron Company, entitled "Notes on Coal Washing Machines," was then read by Mr James Tweedie, engineer, Carron Company :—

NOTES ON COAL WASHING MACHINES.

By David Cowan.

In July of 1886 various coal washing machines were inspected, samples of coal and dross taken, both before and after washing, also of the rubbish washed out of dross, with the object of having these carefully analysed at the laboratory at Carron Works, in order to ascertain the actual work performed by each machine. The results of these analyses are shewn in statement No. 1 appended. The 12 machines inspected were those in operation at the following collieries, the name of maker of each being also given :—

No.	Name of Colliery.	Maker.
1.	Tannochside, Uddingston, - -	Bell, Wishaw.
2.	Woodend, Bathgate, - - -	Coltness, Iron Co.
3.	Devon, Sauchie, - - - -	M'Culloch, Kilmarnock.
4.	Kinneil, Bo'ness, - - - -	Sheppard.
5.	Tursdale, Durham,- - - -	Bell & Ramsay.
6.	Howle, East Durham, - - -	Ramsey, E. Howle.
7.	Binchester, Bishop Auckland, -	Robinsons, Bp. Auckland.
8.	Auckland Park, Bishop Auckland,	Robinsons, Bp. Auckland.
9.	Black Boy, Bishop Auckland, -	Robinsons, Bp. Auckland.
10.	Great Western Coy., South Wales,	Sheppard.
11.	Dowlais, South Wales, - - -	Coppee, Brussels.
12.	Carronhall, Falkirk, - - -	J. Clelland, Carronhall.

The above washing machines may be divided into four distinct classes, viz. :—

(1) The Bash Washer, of which Nos. 1, 2, 3, 4, 10, and 11 are examples.
(2) The Open Trough Washer, of which Nos. 5, 6, and 12 are examples.
(3) The Rotary Washer, of which Nos. 7, 8, and 9 are examples.
(4) The Feldspar Washer, No. 11 being the only example. This is a modified or improved form of Bash.

The Bash Washers.—These are supplied by different makers, but all are much alike in construction, the main difference being in the bashes or cylinders for agitating purposes, some of which are vertical and others horizontal.

The first costs of these machines are much alike, and to erect any one of them complete, capable of washing 200 tons of dross per day, should cost about £500.

From the results of the experiments conducted in the laboratory at Carron, which are shewn in statement No. 1 appended, the Sheppard machine (which comes under this class) in the process of washing removed only 39·9 per cent. of the total rubbish in the dross. The Woodend machine, according to figures supplied, removed 45 per cent. of the total rubbish. See statement No. 1, page 11.

The rubbish taken out of the dross by these machines contained dross to the extent of, as sampled at Kinneil, 4·25 per cent.; Devon, 30·13 per cent.; Woodend, 23 per cent. In comparing these figures it has to be borne in mind that the dross unwashed contained 15·37 per cent., 39·26 per cent., and 20 per cent. of rubbish respectively.

As regards the percentage of dross mixed with the rubbish taken out by the washers, the Sheppard machine gives fairly satisfactory results, but none of them can be considered satisfactory, so far as removing the total quantity of rubbish in the dross is concerned. The cost of washing by these machines varies from 2d to 3d per ton on the washed dross, not including cost of water, which averages 200 gallons per ton of dross washed.

The Trough Washers are perhaps the oldest form of washer in existence, and are, up to the present day, largely in use. There are many forms and types of these washers, but the experimental washer at Carronhall—a trough with a stream of water and dams across—is perhaps the oldest form.

Many improvements have been made from time to time, one of which is the method of agitating the dross as it passes through the trough, notable instances of which are those in use at East Howle and Tursdale Collieries.

The cost of these machines to wash an output of 200 tons of dross per day varies from £250 to £400.

Reference to statement No 1, will shew that some of these washers give very fair results, the Tursdale washer removing 75·44 per cent.; Carron, 68·92 per cent.; and East Howle, 46·80 per cent. of the total rubbish contained in the dross. It has to be noted in making comparisons of these percentages that the dross at Carronhall contains about 10 per cent. less rubbish than the others.

The writer is of opinion that much better results would have been obtained from the machine at East Howle if it had been kept working on a smaller quantity of dross, as there was little doubt the machine was washing up to something like 20 per cent. over its capacity. This is further shewn by the fact that in the rubbish delivered from the machine no trace of dross was found. The percentage of dross left in rubbish taken out by the Tursdale machine was 13·38, and by Carron 9.14. See statement No. 1.

The cost of washing by these machines was given by the parties using them as follows:—*East Howle*, 1·8d per ton of coke, equal to 1·1d per ton of washed dross. *Tursdale*, 1·5d per ton of coke, equal to 0·9d per ton of washed dross.

The cost at Carron is 7d per ton, no doubt due to the crude state of the plant and that manual labour is employed in agitation.

These costs include enginemen and all other labour and stores.

The quantity of water used is about 350 to 400 gallons per ton of dross; depreciation and establishment charges are not included.

The "Rotary" Washer is that patented by Mr Robinson of Howlish Hall, and is in operation at Binchester, Auckland Park, and Black Boy Collieries, in the County of Durham, and at the Bothwell Pits of Messrs Baird of Gartsherrie. This washer is in the form of an inverted frustum of a cone 8 to 10 feet in diameter at top, tapering to 2 feet diameter at bottom, and fitted with necessary outlet valves at bottom of cone. In the centre of the cone revolves an agitator, the washed coal flowing out at the top of the cone and the rubbish being removed from the bottom.

The whole of this plant is very compact and takes up little space, and can be fitted up complete for an output of 200 tons per

day at a cost of about £250, including pulsometer pump. This form of pump is preferred as being less liable to get out of order.

Referring to statement No. 1, it shows that this washer according to the samples taken, has not given very good results, removing only 33 per cent. of the total rubbish in the coal. There is, however, very little coal left in the rubbish, the percentage being 3·80. It should be noted that this is a very dirty dross, the rubbish being 27·23 per cent.

The cost of washing with this machine is said to be fully ½d per ton of dross washed. This, I think, is a low estimate, and I think it might be taken at 1d per ton.

The quantity of water used is a constant one of about 10 gallons per minute, or about 30 gallons of water per ton of dross washed.

From the compactness of this washer, its small first cost and the low working expenses, it is worth consideration. The writer has been informed that better results have been got from this machine than those stated above.

The Feldspar washer is that patented by Mr Coppee, and until recent years, was not in operation in this country. This machine is made in two forms—one to wash coal of sizes from 5 inches to ⅜ inches, and the other, called the Feldspar washing machine to wash coal of sizes from ⅜ inch down to impalpable powder.

This machine was inspected at Dowlais Iron Work, where it is fitted up to wash 1000 tons per day, and comprises two sets of plant, viz.—one for washing bituminous coal and one for steam coal.

The coal in both plants is divided into five different sizes; this being accomplished by the use of revolving screens, reciprocating tables and pointed boxes. Each size is washed in separate compartments. These are constructed of timber and divided into two divisions, the one being the washing compartment and the other the piston compartment.

The piston has a speed of 60 to 75 strokes per minute, and the length of stroke is varied from 1¾ inches to 4 inches, according to size of material to be washed, by an arrangement of a

cranked lever, similar to that used in an iron shaping machine. The speed of the up stroke is much less than that of the down stroke. The rubbish is drawn off continually and automatically from the machine.

The Feldspar machine is used for washing the sizes of coal from ⅜ of an inch downwards. These are much of a similar construction to the foregoing washer, but are fitted with screens, which are covered with a bed of Feldspar 3 to 4 inches thick, through which the rubbish is drawn.

This machine is the only one in which the division of coal into different sizes has been carefully gone into, and that there is a decided advantage in this there is no doubt.

The cost of such a plant for washing 200 tons per day has been estimated by Mr Coppee at £1900. There will, however, be the whole of the foundations, buildings, &c., which are not included in this tender; the total cost for the whole erected complete at Carron may be about £2,500.

Referring to statement No. 1, it will be seen that the best results were got from this washer. In a dross containing 22·64 per cent. of rubbish 85·69 of the total was washed out, which contained 5·70 per cent. of coal.

Mr Coppee guarantees his washer to remove rubbish in the coal to within four per cent. of the total. Our experiments were even a little better than the guarantee, viz., 3·24 per cent. They, however, show that instead of two per cent. of coal in the rubbish there was 5·70 per cent.

The cost of washing by this machine is said to be about threepence per ton of washed dross. The quantity of water used is about 300 gallons per ton of dross washed.

Statement No. 2, shows the relative cost of the different washing machines, the cost of washing per ton of crude dross washed, the quantity of water used by each, also the cost per ton of washed dross to redeem the capital charge at 10 per cent. per annum on an output of 30,000 tons per annum, or 100 tons per day—an output not likely to be much exceeded in the case of Carronhall Colliery for many years to come. It shows also the total loss per ton on washed dross due to loss in process of washing.

The total cost of washing by these several processes is calculated to be as follows :—

MAKERS.	WHERE IN OPERATION.	PENCE PER TON.
Bell, Wishaw, - - -	Tannochside, - -	4·6
M'Culloch, - - -	Devon, - - -	4·48
Carlton Iron Co., - -	East Howle, - -	1·24
Bell & Ramsay, - - -	Tursdale, - -	1·27
Bolchow, Vaughan & Co.,	Binchester, - -	1·48
Coppee, - - - -	Dowlais Coy., -	5·3
Sheppard, - - - -	Kinneil Iron Co., -	2·5
Carron Co., - - -	Carron, - - -	7·6

In carrying out the experiments in the laboratory at Carron, from which the foregoing conclusions have been arrived at, the method adopted of ascertaining the quantity of rubbish contained in the samples of coal was by the use of a liquid having a specific gravity greater than that of coal and less than that of rubbish. The liquid used was glauber salts saturated with sulphuric acid having a specific gravity of 1·400.

That a liquid having this specific gravity is likely to have the tendency to separate the rubbish from the coal is shown by the fact that the specific gravity of the coal samples ranged from 1·164 to 1·388, the average being 1311, while the rubbish ranged from 1·791 to 2·374, or an average specific gravity of 2·050.

The foregoing is the result of my own inquiries, and of the information supplied by me. The samples were taken by me, and the laboratory examinations were conducted under my supervision. The results given are on this basis. They pretend to be neither more nor less than what came within the range of my own observation. I trust some members of the Institute will follow up the matter, aud that in time we may get some data which may be of general use to the members and induce them to go in and improve the manipulation of coal so as to economise its use.

Statement No. 1.—Shewing the quantity of rubbish in dross previous to washing at the following collieries, and the rubbish left in dross after washing; also, coal in rubbish removed by washing and percentage of total rubbish washed out.

Name of Colliery.	Name of Washing Machine.	Rubbish in dross coal previous to washing.	Rubbish left in washed dross coal.	Quantity rubbish removed by washing operation.	Coal in rubbish removed by washing.	Total rubbish and coal taken out in operation of washing.	Percentage of total rubbish in dross taken out in washing.	Weight of dross lost as being mixed with rubbish taken out in operation of washing on every 100 tons washed.	Weight of rubbish left in every 100 tons of washed dross.
		Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Tons. Cwts. Qrs.*	*Tons. Cwts. Qrs.*
Dowlais, -	Coppee, - - -	22·64	3·24	19·40	5·70	25·10	85·69	1 8 2	0 16 0
East Howle,	Ramsay Trough, -	25·35	13·51	11·84	Trace.	11·84	46·80	Trace.	1 11 3
Binchester,	Robinson, - -	27·23	18·24	8·99	3·80	12·79	33·00	0 9 2	2 6 2
Tursdale, -	Bell & Ramsay Trough,	13·84	3·40	10·44	13·38	23·82	75·44	3 3 2	0 16 0
Kinneil, -	Sheppard, - -	15·37	9·06	6·31	4·25	10·56	39·90	0 8 3	0 19 0
Devon, -	M'Culloch, - -	39·26	...	...	38·13	...	...	...	...
Carron, -	Trough, - - -	14·32	4·45	9·87	9·14	19·01	68·92	1 14 2	0 16 3
Woodend, -	... ...	20·00	11·00	9·00	23·00	32·00	45·00	7 6 0	...

Statement No. 2.—Shewing the relative first cost of the different washing machines, the cost of washing per ton of dross, the quantity of water used, the cost per ton of washed dross to redeem the capital outlay at ten per cent. per annum, calculated on an output of 30,000 *tons; also, loss per ton in dross washed out with rubbish, and annual value of dross lost i washing.*

Name of Washer.	Total Cost.	Quantity of Water used per Ton.	Loss per Ton in Dross left in Rubbish, calculated at 2s per Ton.	Cost of Washing per Ton.	Cost per Ton of Dross to Redeem Capital at 10% 30,000 Tons per Annum.	Total Cost of Washing per Ton.
Bash Machine—			*	*	*	
Bell & Sons, at Tannochside, - - -	£500	200 gns.	1·7d	2½d	·4d	2·9d
M'Culloch's, at Devon, - - - -	600	200 ,,	say 1·0d	3d	·48d	3·48d
Trough—						
East Howle, - - -	300	350 to	nil	1d	·24d	1·24d
Tursdale, - - - -	250	400 ,,	·7d	1d	·20d	1·20d
Rotary—						
Robinson, - - - -	250	30 ,,	·2d	1d	·20d	1·20d
Feldspar—						
Coppee, - - - -	2500	300 ,,	·3d	3d	2·00d	5·30d
Sheppard, - - - -	500	—	·1d	2d	·4d	2.40d
Carron—						
Experimental, - -	—	—	·4d	7d	—	7·40d

* Labour, cost, and depreciation only included, power and other establishments charges not included.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

31st January, 1889.

JOHN M. RONALDSON, Esq., President, in the Chair.

The minutes of the last General Meeting were read by the Secretary and confirmed.

The following discussions then took place :—

DISCUSSION OF DR. T. G. NASMYTH'S PAPER ON "THE AIR OF COAL MINES."

THE PRESIDENT said that Dr Foster, the Inspector of Metalliferous Mines in Wales, although not a member, intended to send a contribution on the subject, as he had gone into this same question of the air in mines. If they were to get this information, it might be interesting. Referring to Dr Nasmyth's reply at bottom of p. 220, to what he (the President) said at a former meeting, he thought either the table must be printed incorrectly, or Dr Nasmyth did not give a satisfactory explanation. At p. 220, the difference was printed 22 degrees, but in the table on p. 182, the difference was given as only 6½.

The SECRETARY said Dr Nasmyth had written him that he intended to pursue the subject as soon as he could get an opportunity.

The PRESIDENT—I am sure we will be very glad to have the results of the Doctor's further investigations.

The discussion was adjourned.

DISCUSSION OF MR HUGH JOHNSTONE'S PAPER ON "LONGWALL WORKING IN THE EDGE SEAMS AT NIDDRIE COLLIERIES."

The SECRETARY read the following communication from Mr Alex. Easton :—

I have been very much interested in Mr Johnstone's paper on longwall seams and the discussion thereon. There is one point, however, which has been touched upon regarding the great pressures experienced in the working of stoop-and room in some cases and not in others—a fact which, to my mind, has not been very satisfactorily explained. It is very evident that the mere weight of the superincumbent strata cannot be the cause of this great local pressure. The mere fact that relief from the extra-

ordinary pressure was obtained, as mentioned in the above paper, in a seam when the one above it was worked first, does not, in any sense, point to weight of strata as having been the disturbing cause, since the extraction of an upper seam cannot appreciably lessen the pressure due to weight of strata on a lower seam. I am inclined to think that the real cause is gas imprisoned in the strata under high pressure. The effect of imprisoned gas at high pressure in a seam of coal in forcing out large pieces of coal with great violence, is a fact familiar to all connected with coal working. The relief of pressure in a lower seam by working of an upper one first is thus easily accounted for by the draining off of the gas by the extraction of the upper seam.

Since reading this paper I have noticed in an English book on mining a case which occurred in England, where the pressure of imprisoned gas was so great as to force a stone measuring 7 ft. by 6 ft. by 4 ft. 1½ in., out of the solid, the pressure of the gas being estimated at about 40 lbs. per square inch.

On the foregoing remarks I would like to have the opinions of members. As to the views I have advanced, if they cannot be accepted as a satisfactory solution of the question, it will at any rate be highly instructive and interesting to us all to be shown that imprisoned gas at a high tension *cannot* produce the effects I have attributed to it.

Mr JOHNSTONE said, with regard to what Mr Easton had said, as to the enormous pressure upon the edge seam workings being probably due to gas imprisoned in the strata at high pressure, he had to point out that, in the Niddrie workings, there was no such thing as gas. Of course, he meant inflammable gas. Inflammable gas had not been found there within the memory of man, and he had never seen anything to indicate the existence of gas of any kind imprisoned in the strata. Of course, they understood where gas was pent up at high pressure, it might produce somewhat similar results, although in his experience pressure from gas concentrated itself at points, and burst out the roof over small areas. There had been cases in the Hamilton district where 5 feet of strong fakes had been burst out suddenly by the pressure of gas. At Niddrie, the pressure was not merely local, but extended over large panels of the workings. He did not think

that this matter had ever been satisfactorily explained, but probably closer investigation would clear it up. His impression was that the pressure and the breaking of the strata were due more to buckling action, such as took place when a long pillar yielded under a load. If they took a pile of thin deals nailed together so as to form a beam, say 12 inches square, and laid it flat on the ground, it would stand enormous pressure, and would only give way when the crushing strength of the material had been exceeded. If, however, they took the same beam, say 60 feet in length, and set it up on end, its own weight would cause it to buckle and break up; and he thought the unusual appearances seen at Niddrie were due more to the excessively high inclination of the strata inducing a similar action than to anything else. If the same metals could be turned over in the flat, he had little doubt the workings could be as easily maintained as any ordinary flat workings. Mr Thomson, in the communication sent in, described the method which had been followed out at Roslin Colliery. He had not given them the thickness of the seam, nor the nature of the roof and pavement. He did not exactly know of what nature his bottom coal was, but he might mention that the method described was the method which first occurred to him when working out this system at Niddrie, and that it was given up by him on the ground that the spouts in the bottom coal would not remain open. The coal was of a soft, friable nature; the gas coal came down in large square joints; and his experience of the bottom coal convinced him that it would be practically impossible to keep the spouts open for a greater distance than perhaps 15 or 20 yards if made in it. Had it been possible to line them with timber, he might have tried this method, but as this was impracticable he gave up the idea. There was just one other point to which he would like to refer. In Mr R. T. Moore's remarks, p. 223, he states:—

"He perhaps felt more interest in the paper from having at the end of 1884 attended a meeting of the Niddrie Coy. and advised the Chairman to work the gas coal at Niddrie by the long-wall method, in the same way as the ironstone was then being worked at the Shotts Coy.'s mines at Penicuik. The Chairman at that time said that he did not see his way to go into

that style of working, and he (Mr Moore) wrote him a report, with plans, showing a style of working suitable for the gas coal, and he was glad to see it had now been carried out."

Those of them who were present at last meeting would, of course, have no difficulty whatever in understanding what Mr Moore meant, but to the large section of members who did not attend the meeting, and who only read the discussion as reported in the "Transactions," it appeared to him that this practically laid him under the charge of having adopted a plan of working recommended by Mr Moore, and that without any acknowledgement whatever. Had Mr Moore been there that night, he would have asked him to explain this. In his absence, he thought it only fair to himself to point out that the style of working suggested by him, and the style of working actually carried out at Niddrie, were entirely unlike in every detail. Mr Moore's plan was, he had no doubt, applicable to the ironstone workings at Penicuik, but, for many reasons which he need hardly go into, it was in his opinion entirely inapplicable to the working of either of these two seams at Niddrie. Mr Moore, of course, cleared that up as he went on, because he described the working at Penicuik, and any one, comparing it with that at Niddrie, would observe that the two methods were entirely unlike. Still, from the wording of the sentence to which he had referred only one meaning could be taken, and he thought it only fair to himself to explain it.

The discussion was adjourned.

DISCUSSION OF MR DAVID COWAN'S PAPER ON "NOTES ON COAL-WASHING MACHINES."

THE SECRETARY read the following communication from Mr F. J. Rowan:—Mr Cowan's paper is both interesting and useful, and it is to be hoped that it will be followed by similar communications from those who have had practical experience of coal washing. So many different methods of washing coal are in use in Scotland that a few accurate results from each would form a body of most useful information and a valuable basis for comparison of different systems. It must be understood,

however, that the results given by Mr Cowan are not by any means the best which can be obtained by modern practice. 5.7 per cent. of impurity in dross should not be accepted as the goal to be aimed at, or as the highest degree of coal purification which has been reached with the best methods. Again, 300 gallons of water per ton of coal washed is an excessive amount, and is one that in many cases would render washing impracticable. In every case, dealing with the water enters into the question of cost, either on account of the power required to move the volume of water, or because of settling ponds to be made and cleaned, or from loss of coal, perhaps from all combined in some cases. The amount of impurity left in the dross also affects its value and the return in money obtained for it. On the Continent very much better results than those mentioned by Mr Cowan are regularly obtained, and it is well known that apparatus for the economical treatment of coal has been there very largely developed of late years. In connection with the historical part of the subject of Mr Cowan's paper, I think it will be of interest to the members to know that the original form of the arrangement now called Robinson's was introduced over twenty years ago by Mr Herbert Mackwork, and is described and illustrated in Vol. III. of Crookes & Röhrig's Practical Treatise on Metallurgy, p. 463, which was published in 1870, and in an earlier issue of Dr. Ure's Dictionary of Arts and Mines (Vol. III., p. 1015). It is said that this "purifier" of Mackworth's saved from 5 to 15 per cent. of coal as compared with the jigging machines or machines having a pulsating movement of the water, and that as the water was used over and over again a very much smaller quantity was required. The cost of washing did not exceed 3d per ton, and the loss of coal did not exceed 2 per cent. In Mr Cowan's paper the felspar machine is ascribed to Mr Coppee, but I have reason to believe that in ascribing this invention to Mr Lührig in my paper on "The Principles of Coalwashing Machines," I was correct. A British patent for this machine was taken out by Mr Coppee, but this was subsequent to the publication of a paper by Mr C. P. Rathbone in Trans. North of England Inst. of Engineers, Vol. XXIX., 1879-80, in which this machine is fully described as part of Lührig's system. Mr Rathbone's paper is in great part a

translation of a complete description of Lührig's system which appeared in the Jahrbuch für das Berg und Hüttenwesen of Saxony in 1878, from the pen of Professor Kreischer of the Friedberg Academy. Mr Lührig has recently written to the *Colliery Guardian* (October 12, 1888, page 517), setting forth the facts as to Mr Coppee's connection with him and his designs, and has stated that Coppee has no claim to be considered the inventor. The illustrations in Kreischer's and Rathbone's papers are reproduced in the drawings of Coppee's British patent. Lührig has, however, considerably improved upon his early designs, although the principle of the felspar machine remains the same.

The SECRETARY also read the following communication from Mr David Cranston:—I have read Mr Cowan's "Notes on Coal Washing," and there appears to me either to be a great mistake in the figures of statement No. 1, or I misunderstand it. I refer, of course, to Woodend washer. The 11 per cent. in the second column is clearly an error, as we coke the washed dross, and the amount of ash in the coke is under 8 per cent. It takes about two tons of dross to make one ton of coke; and if the 11 per cent. were correct, then the ash in the coke would be over 22 per cent. plus the amount of ash in the coal naturally, which cannot be removed by washing. The analysis of the washed dross gives fully 4 per cent. of ash, or equal to about 8 per cent. in the coke, thus proving that all the rubbish is washed out. I have not sufficiently tested the percentage of rubbish which is in the dross previous to being washed, so as to be able to say whether 20 per cent is correct; it is a variable quantity, and may be low if sampled at one time of the day and high at another, but I will take it that 20 per cent. is about the average. Then, as to the figures in the fourth column, the 23 per cent. should not be put down as coal. I made an experiment once by rewashing a whole day's output of the rubbish, and found therein 23 per cent. of coally matter, not coal, the object being to find whether this coally matter is of any value, but it would not coke, and when tried in the boiler fires it would scarcely burn, sparking badly and damping down the fires; in fact, the 23 per cent. was chiefly composed of a black coally blaes, and I think that not more than 5 per cent. of it was coal. I cannot understand how Mr Cowan

arrives in the fifth column at 32 per cent., unless by adding the third and fourth columns together, but to do so appears to me to be incorrect. As I take it, the fourth column gives the percentage taken out of the third column, or, in our case, 23 per cent. of 9 per cent. = $9 \times 23 = \frac{207}{100} = 2{\cdot}07$ per cent. $+ 9 = 11{\cdot}07$ per cent., it should be, instead of 32 per cent. I understand how he arrives at the figures in the sixth column, but I cannot make out how he finds those in the seventh column. From my way of looking at it, the 7 tons, 6 cwts. should only be 23 per cent. of $9 = 2{\cdot}07$ tons; but to go back to my own figures, which I believe to be about correct, the statement as to Woodend washer should be as follows :—

1.	2.	3.	4.	5.	6.	7.	8.
			ABOUT			TON.	
20·00	0·00	20·00	5·00	21·00	100 %	1	...

The PRESIDENT, with reference to the samples taken, asked Mr Cowan if he considered them fair, average specimens of the material dealt with.

Mr COWAN—They were very fair, average samples of the material dealt with. He had had a good deal of practice in the taking of samples, and he was perfectly satisfied they were fairly taken. Proceeding to reply to one or two things in the communications just read, Mr Cowan said it was about two years since he had gone into those matters, and so many things had passed through his mind since, he had in a great measure forgotten the subject, but he was sure that at the time the matter was most carefully gone into. Mr Rowan had stated that those results were not such as could be attained in modern practice. Well, this was the practice at the places he had visited about two years ago. Certainly, most persons with whom he conversed on the subject seemed to think they were doing well, and they gave him every opportunity of examining the machines for himself. He was not in a position to discuss matters with them, but he listened to everything that was said and took samples, which were sent home and subjected to a careful series of laboratory experiments. The results, as given in those tables, were correct as regarded the particular samples operated on. Of course, he quite understood that the machines would give different results at different times,

depending to a great extent on the attendants and the amount of coal passed through them in a given time. If a machine was being pushed, in many cases it would not give such good results as when not pushed, and the treatment of one kind of coal would give different results from the same treatment of another class of coal. He had no doubt those who had had general experience on the subject would agree with him in saying that almost every locality and every coal required special treatment, and every machine had its own good points, and required certain special adjustments to deal with the particular coal. For example, if one worked coal dross, say to make nuts for sale, that was not so important an operation as one where they required to make coke as free from ash and sulphur as possible from a very dirty coal containing much sulphur which would be suitable for iron making purposes. Mr Rowan spoke about the names of the inventors of those various machines. The names he placed opposite were those by which they were popularly known in the respective localities he (Mr Cowan) had visited. He had no doubt, however, Mr Rowan, historically, was quite correct. As regarded what Mr Cranston had said, what he had stated about the sampling applied equally to his case. It was very likely he had been unfortunate in taking them on an unfortunate day, but these were the results obtained from the samples he took. In regard to the cost of weighing, that at Carronhall, viz., 7d, was rather high. The apparatus had since been modified, and an additional quantity of coal could be put through it. The cost now ran very much the same as in the case of other machines.

Mr Forgie said that, with regard to the Robinson machine, Mr Cowan said he visited Messrs Bolchow & Vaughan's Collieries at Bishop Auckland, where these machines are working, and took samples and the information as he got them. These machines, where the samples had been taken, must have been in a very unsatisfactory working condition at the time of Mr Cowan's visit. In his statement (No. 1, p. 235), Mr Cowan gives the proportion of rubbish in the dross before washed as 27·23 per cent., and after washed as 18·24 per cent.—the proportion of rubbish taken out by washing being thus only 8·99 per cent. of the dross, or 33 per cent. of the total rubbish in the dross before being washed.

We have had considerable experience with the Robinson washing machine at several of our works. After seeing them working at Bishop Auckland, so satisfied were we with them that we have since erected a number of machines at our various works, and were, perhaps, the first firm—in Scotland, at least—to adopt them, and I would be sorry to have to say now that we were only taking a third of the rubbish out of the dross. We wash all kinds of dross, containing all kinds of rubbish, from light sclits to heavy pyrites and fire-clay—the rubbish varying from as low as 2 and 3 per cent. to as high as 16 and 18 per cent. of the dross—and we in all cases wash the rubbish out sufficiently to make dross, which was almost unmarketable, of a good marketable value. The coking dross at Kilsyth contains a very small quantity of rubbish, and we only washed out equal to 2 per cent. of the dross, and this washing cleaned the dross so that coke made from it contained almost as little ash as that from coke made from the round coal which contained no dirt further than that natural to the coal, and which no amount of washing with any machine whatever could possibly take out. Dross in the Bothwell district was also washed, containing from 7 to 16 and 18 per cent. of rubbish, and so effectually that, except in the small gum, almost no rubbish was left. Even the gum itself, over several months' trial—in which the actual quantity consumed was estimated, and the actual ashes drawn from the boiler fires weighed—only showed from 8 to 11 per cent. of ashes, which, I think, is a very good result, as the gum by no means undergoes perfect combustion in boiler fires. I am very much afraid Mr Cowan's samples cannot be true samples, as it was not likely that a firm such as Messrs Bolchow, Vaughan, & Co. would be satisfied with machines which gave such results as stated in Mr Cowan's paper, when 18·24 per cent. of rubbish was left in the dross after washing, and more especially with a dross which was used for coking purposes. Independent of the ash natural to the coal itself, which might safely be taken at 4 per cent., the 18·24 per cent. of rubbish in the dross would give in coke (taking 30 cwts. dross as necessary to make a ton of coke) 27·36 per cent. of ash. Add to this the ash natural to the coal, and you have coke, made from Bishop Auckland washed dross, containing 33·36 per cent. of ash, which

would be useless in any furnace or founder's cupola for iron-making. Referring to Mr Cowan's estimate of the cost of erecting a Robinson washing machine, perhaps it was low enough. I find that we could never succeed in erecting a machine for £250, even of the smallest size. Our first was a six-foot machine, and was erected under very favourable circumstances as regards position, for we managed to get it right under the screen, and high enough to deliver the washed dross into the waggons—thus avoiding the necessity for elevating machinery—and with a small engine, intermediate gearing, pulsometers, and the necessary steam and water piping, this machine cost something like £395. This sum did not include the patent royalty. This was the smallest machine made, and its cost in our case was double Mr Cowan's estimate. We might now be able to fit up one, under the same conditions, for £50 less, owing to the experience we had gained. Washing machinery was, however, a very small part of the machinery now erected at some collieries for the handling of coal and dross.

Mr GILCHRIST said Mr Cowan might explain how the rubbish was treated. There was such a difference shewn in the fourth column that probably a little explanation might make it clearer. If Mr Cowan broke up his rubbish while treating it, this might give him a greater percentage of coal in the rubbish, and yet the machine in every case be doing nearly perfect work. For instance, in washing some of the coals the rubbish may be perfectly free, and in other cases the bands of dirt and pyrites so intermixed with the coal that if Mr Cowan broke that up he would get the coal, and that might increase the percentage of coal in the rubbish. There was another point as to the cost of the machines. Mr Cowan's cost might be a comparative statement of what they could be done for. In connection with Robinson's machine, he took it that it was capable of washing 200 tons a day. For that machine they required a pulsometer, the cost of which was £100; they paid £80 for the royalty, which made up £180. Then they had engines, elevators, and all the erections necessary for a large cistern 30 feet above the top of the washer, and he quite agreed with Mr Forgie that they must put the price at a much higher sum. There had evidently been some great mistake made on the point of cost.

Mr FORGIE said regarding the rubbish in the coal in the Hamilton district—the Ell coal and the Main coal—having pyrites, there was a large quantity of coal in the rubbish, and it was apt to pass sticking to these. But in the coking coal they could submit samples of dirt almost free of coal, and with a careful man at the washing machine, he could so time the opening of his valves that there was no dirt left in the coal, and no coal left in the dirt.

Mr THORNEYCROFT said he would like to ask how the samples were taken with the view of getting comparative experiments with those from other places. In taking samples there was a difficulty in drawing them, but if all were taken the same way they would be comparative. With regard to the amount of dirt taken out, at Merryton, they had a Robinson washer, and the amount of dirt left in the coal that came through the riddles was down to about 1 per cent., and that was nearly all in the small size (peas and gum).

Mr FORGIE said the Robinson machine had an advantage over any other, in the fact that there was so little water used. It was constantly being pumped back. It circulated from the trough to the machine. Very little coal was lost, the most of the water was passed through fine sieves, when the gum could be got and used for firing purposes. Again in washing the coking coal, they preserved the whole of that small stuff, because they ran the whole of the water into the waggons the dross was being put into, and as the water passed through, the dross acted as a filter, and caught the whole of that fine stuff. Of course that was a great improvement, as they lost almost none of the fine coal.

The PRESIDENT asked what about the farmer's water? Was there nothing to be said regarding the various machines on that subject?

The SECRETARY said it was desirable to have a machine that did not pollute the water, because agriculturists were apt to complain,—as a matter of fact, had complained.

Mr GILCHRIST said, as far as that was concerned, it was easily arranged. As to the quantities of water, there were certainly considerable quantities used in some cases. He took it that these had plenty to make use of. If they had less, they would

adopt the same system as with Robinson's machine and pump it over and over again. Accordingly, he thought the quantities of water used were certainly misleading. As to the remark regarding the gum running away, he was very much troubled in that same way. At one time he considered that 5 per cent. of the very fine stuff was often run away into the settling tanks. He had been much annoyed at that, for, besides the loss, there was considerable expense in cleansing it. However, they easily got over that. They recovered the whole of it, and, if it was a coal suitable for coking, he believed it would make the best of coke. Of course, they might have adopted Mr Forgie's plan, and run it into the waggons. When they pumped the water over and over again, and only a little water escaping, it was very easily purified. He had seen it flow over a grass field and not leave a mark behind.

Mr JOHNSTONE asked how it was that, if the water was so easily purified, the Clyde was as dark at Bothwell Bridge as at the Broomielaw?

Mr GILCHRIST—Probably they have plenty of water.

Mr COWAN said Mr Forgie had brought up the matter of cost of the washing plant. The question of cost was something like the old question—"What is Truth?" The cost he had given was simply that of the machine itself placed in position, but fitted up without many auxiliaries such as pumping engines, screens, carriers, &c., or anything of that kind. They might fit it up elaborately or simply according to the ideas of those concerned. It was a very awkward thing to take unreliable costs of plant from any one even when they were pretty well considered. He found in practice that they varied from 25 to 50 per cent. higher than the original estimates, and this, in a measure, was due to the development of ideas. As to Mr Gilchrist's question, the samples were broken up so far only as necessary to carry out those experiments in the laboratory. Mr Forgie also referred to the gum getting away. At several places, particularly East Howle, they had a very elaborate system of settling tanks, which, had they been added to the cost, would have been far more than the machine itself; but certainly they were very effective for the purpose. They intercepted a large quantity of gum, and it so happened to be a coking coal, and if this gum when put into the

oven by itself made a very good coke, but was so much denser than the ordinary coke, it was not very suitable for the purpose to which it was applied, and consequently the gum was usually mixed up with the ordinary coking coal. Mr Thorneycroft referred to the taking of the samples. He should say they were taken in a very careful manner from the waggons. He was perfectly alive to the necessity for exercising great care in taking the samples, and during the course of his experience, at one time being responsible for the sampling of 2000 and 3000 tons a day, he must say he had got his education there pretty well completed. In sampling the coals in question he exercised as much care as he possibly could. Robinson's machine was certainly that which used least water. It was well suited for nuts and large coal, but so far as he was able to see it did not do so well with the small coal. The machines he inspected were at Binchester Colliery, and he understood shortly after some members of Mr Thorneycroft's firm had been there and inspected four or five machines. The machine there might have been working badly, but certainly the samples were fair samples of the work going through the machines on that occasion. A principle, only carried out in the Coppee machine, was that of sizing the coal previous to washing. This seemed most essential, if the best results were desired.

Mr HASTIE said it was advisable that members should know that the Council had appointed a Committee to investigate the matter of coal washing. Mr Cowan had brought forward valuable information, and he thought it would be well that the members should know before next meeting that every one would have an opportunity of bringing forward information.

Mr GILCHRIST said the Committee were appointed to report on coal cleaning, not washing merely.

The PRESIDENT—The Committee is to take into account everything connected with the preparing of coal for the market.

The SECRETARY said Mr Cowan had put his paper at the disposal of the Council, either as a separate paper or as part of the information which might be used by the Committee on coal cleaning. The Council chose to put it in as a separate paper, as it would serve as an introduction to the general question.

The discussion was adjourned.

The following paper on "Air Vessels" was then read by Mr Dugald Baird.

AIR VESSELS.

By Dugald Baird.

In November, 1882, Mr M'Creath read a paper to this Institute on "The Sucking Power of the Common Pump, and on some of the Shocks which occur in Pumping," and, in discussing this valuable paper, a great deal was said about the utility of air vessels on pumps and pipes. As this part of the discussion was really beyond the scope of that paper, Mr M'Creath did not give so much attention to it as he would otherwise have done. Much useful information was, however, given during the discussion, and it appeared that there was plenty more to follow, if the subject were brought up again. Combining this with the fact that I am aware that there is a variety of opinions among mining managers as to the utility of air vessels, I venture to present a few observations on this subject.

During the past six years I have had an excellent opportunity of studying the action of various kinds of pumping machines under many varying conditions, and, for the purpose of ascertaining the exact pressures and strains inside the pumps and pipes, my employer asked me to register these from time to time, and, to do so, a large number of diagrams were taken off steam cylinders, pumps, and pipes, and it is upon these that the observations are based.

We have had, during the time mentioned, 35 different pumps at work, and have at the present time 27. Twenty-one of these are in operation night and day, and 6 are ready to start at a moment's notice. Their capacity varies from 40 gallons per minute up to 1200 gallons per minute, and our total growth in ordinary weather is 3000 gallons per minute. From the notes kept of the working of these pumps, we are satisfied that the air vessel plays a most important part in the working of pumps; and I propose to give the results of these inquiries, and the conclusions come to, based upon them.

The primary object of the air vessel is to soften the shocks that occur inside the pumps and pipes of a pumping machine, and thereby equalise the pressure that is necessary to force the water up to the delivery.

Although air vessels have been in use for many years, a large number of managers say that they are of no use, and some even say that the pump goes better without them. No doubt there are reasons for these various opinions, and these, for the most part, will be found to arise from the fact that the air vessel is either badly placed, or badly attended to, or too small, or it may be that the motion in the pump and pipes is so slow that an air vessel is actually not required. The following are some of the instances where the proper action of an air vessel was shewn to be of great service :—

I.—At Kelty No. 1 Pit: a 12-inch combined plunger and bucket dook pump, where the motion was given by means of wooden rods. The bucket and ram had a velocity of 100 feet per minute, and the water in the discharge pipes had a velocity of 144 feet per minute. The length of the column was 200 yards, and had a vertical height of 28 fathoms. There was an air vessel on this column, but it was fixed on the side of the pipes, and so could not trap the air that came up with the water, and there was no means of charging applied. This pump nearly always worked roughly, and the wooden rods were often broken; the spur wheel of the engine also snapped, and was renewed with a steel one; and three strong clack-pieces were burst. It was ultimately suggested that perhaps the air vessel was not doing its duty, and, having no other method of testing, the oversman ran off the column. This was found to do a great deal of good, as it caused the pump to go very much easier; and he also found that this had to be done every third day, and that, if he allowed it to go longer, the pump began to work roughly, as before. It was a clear case of all the air that was in the air vessel escaping away with the water, and the pump, being left without a cushion for the shock caused by the high velocity of the water, went rough. This arrangement of running off the column was carried out until the pump was no longer required, and there is no doubt that it prevented a large

number of breakages. No diagrams were taken off this pump, but, from a pressure gauge put on the pipes, the pressure was seen to be three times the statical pressure when the air vessel was not acting. After this, it was thought desirable to procure diagrams, which would show the pressure at different parts of the stroke, and M'Naught's engine indicator was used for the purpose, with good results.

II.—The second case was that of the same class of dook pump, at Pirnie: a 10-inch combined bucket and ram pump, which had a velocity of 96 feet per minute, while the water had a velocity of 192 feet per minute. The column was 200 yards long, and had a vertical height of 15 fathoms. There was an air-vessel attached to this pump, which was charged by means of an air-cock on the suction pipes, and the whole arrangement worked very well until the growth of water got too great for the pump going at a proper speed, and by and bye the air-cock got drowned. After a day or two the air evidently got exhausted from the air-vessel, and heavy shocks came on to the pump and pipes, and could be heard and felt even at the delivery end of the pipes. Owing to this extra pressure on the bucket, the pump did not pump so much water, and before the cause was detected, and a remedy thought of, the pump itself was covered with water, and it looked very like as if the pump was to be lost. A hole was, however, bored into the barrel, and this hole was tapped, and a piece of pipe, long enough to be above the water, was screwed into it. On the end of this pipe a self-acting valve, which admitted air but shut during the back stroke, was fixed, and in ten minutes the pump was going as smoothly as ever it did, and mastered the water.

Diagrams were taken off this pump, and show most distinctly the benefit of the air-vessel when filled with air. With the air-vessel, the greatest pressure registered was 48 lbs. per sq. in., while without the air-vessel the greatest pressure was 90 lbs. per sq. in., the statical pressure being 38 lbs. per sq. in. These diagrams are shown on Figures 3 and 4, Plate VII.

III.—This case was that of a 10-inch double-acting plunger

pump going at 54 feet per minute, with the water in the pipes flowing at 150 feet per minute. The statical pressure was 104 lbs. per sq. in.

The air-vessel in this case could not be placed nearer than 20 feet from the first discharge clack and 35 feet from the other one, and still with such a slow speed of pump, and such a great distance from the clacks, the highest pressure without the air-vessel was 55 lbs. per sq. in. greater than with it. These diagrams are shown on Figures No. 5 and 6, Plate VIII. The column of this pump is 480 yards long, and has a vertical height of 40 fathoms. There is also another large air-vessel fixed on the discharge column about midway up. This second air-vessel was in working order when both No. 5 and No. 6 diagrams were taken. An air-vessel is also attached to the suction pipes of this pump, and the same diagrams show the benefit of having an air-vessel on the suction pipes, especially where they are long or small in diameter, or where the pump has to lift its water a great vertical height, or where the ram is moving very fast.

In the case referred to, the suction pipes are only one inch less than the ram; the height of them, 100 feet; the vertical height the water is lifted, 15 feet.

Fig. 5 shews the pressure without the air-vessel to vary from 8 lbs. to nothing below atmosphere, whereas No. 6 shews that the pressure with the air-vessel on only varies from 9½ to 9 lbs. below atmosphere, and as a consequence of the steady suction the pump is able to pump more water. It was found that, after this air-vessel was put on to the suction, the pump could keep out the growth of water with half a stroke less speed, being reduced from 6 strokes to 5½ per minute.

IV.—The diagram shown on Figure No. 9, Plate IX., is taken from Kelty 20-inch double-acting plunger pump, with a vertical head of 90 fathoms and having a large air-vessel, which could not be fixed nearer than 90 feet from the clacks. This diagram shows the extra pressure required to lift the valves or clacks. The other diagrams already mentioned do not show this, because the pressure necessary to push the water through the discharge pipes is greater than that required to lift the clack, and so the pressure

inside the casing does not fall the moment the clack lifts as it does in this case. The statical pressure is 234 lbs. per sq. in. The pressure required to lift the clack is 300 lbs., but the moment the clack lid lifts, the pressure falls down to 270 lbs., which is the pressure necessary to push the water up the column of pipes, the pipes being 17 inches in diameter.

At first there was no air vessel on this pump, and there was great difficulty in keeping the joints tight between the rams, which were horizontal, and the delivery pipes, which were vertical. There was no diagram taken before the air vessel was put on, because up to that time we had no instrument but the M'Naught indicator, which was insufficient to register these pressures. A hydraulic pressure gauge was, however, put on, and it was found that although the statical pressure was only 234 lbs., the gauge registered regularly 400 lbs., and occasionally 600 lbs. per sq. in. The diagram, Fig. 9, taken with the hydraulic indicator sketched at Plate X., shews how great is the improvement with the air-vessel. Plate XII. shews the type of engine and pumps referred to in this case; and as I believe it is the only case of the combination of Davey's horizontal compound surface and underground engines in one, it may be interesting to those who, like Mr Carlow, whose general design it was, do not like to risk a large engine at the bottom of the pit, where the growth of water is so heavy as to give little standage to prevent drowning in case of accident. The stroke is 7 feet, cylinders 42 and 66 inches in diameter, steam pressure 65 lbs., diameter of ram 20 inches. The bell cranks work 17 inch and 15 inch buckets from the lower seams, which are 20 fathoms and 40 fathoms distant respectively. It has been found to work very satisfactorily. Before the air vessel was put on, the level of the water in the column at the delivery end never fell below the level of the delivery pipe; but since it was put on, the water dances up and down the pipes from 3 to 5 feet every alternate stroke, having the appearance of the column of water resting on a spring. When it was first put on, it was found that this vibration took place, but every day it vibrated less, until at the end of a week there was no vibration at all. This was owing to the air in the air-vessel getting exhausted, the cause of which was a dip in the

delivery pipe *a*, Plate XII., and a separate air pipe *b* was found to keep the air vessel always charged, the air being got either from any leak in the ram stuffing boxes or when the engine was going on air, or by a small cock on the suction pipes for the purpose, when going solid continuously for some days.

As already mentioned, Plate X. shews the hydraulic indicator used for taking the diagrams under high pressures. It had to be made specially to order by Schaffer and Budenburg, as all our efforts at finding such a machine were without success. It is simply the same arrangement for fixing the paper, and the pencil for marking it, as the Richards' indicator, with a hydraulic pressure gauge attached to indicate up to 3000 lbs. per sq. in. The mode of attachment will be readily followed from the sketch.

V.—The diagrams shewn in Figs. 7 and 8, Plate IX., are taken from the ram casing of the surface pump of a Moore hydraulic pump, and shew a reduced maximum pressure with a piston air vessel as against its working without an air-vessel. This pump is worked by a beam condensing rotary engine, geared 4 to 1, and it was found that the momentum of the fly-wheel carried on the rams and caused shocks which with a direct acting Davey engine would not have occurred. It was to relieve the pump from these abnormal shocks that the air-vessel was put on, which it does to a great extent when properly charged.

Air-vessels to be of any use must be kept constantly charged with air; and, while there are many ways of charging them, there are five which I would recommend, partly from actual experience, and partly suggested from that experience.

1st—Running off the column of water.
2nd—By means of a pet cock on the suction.
3rd—By the system shewn on Fig. 1., at *C*.
4th—By the system shewn on Fig. 1., at *D*.
5th—By means of a small air pump.

The first method is certainly a very clumsy one, but it is, nevertheless, often used. It also makes it necessary to have an air-vessel of great capacity, seeing that with a heavy head the air

is compressed into such small volume—for example, with a head of one hundred fathoms the air, after the column is full, if let in at atmosphere pressure would only occupy $\frac{1}{18}$th of the area of the air-vessel; or, in other words, if the air-vessel was eighteen feet long, the air would only occupy one foot at the top, which is not sufficient to be effective, unless the sectional area is all the greater.

The second method of charging is a most convenient and effective plan, and, unless when the head is over one hundred fathoms vertical, is found to serve the purpose well. The air is drawn in in small quantities, either at the pet cock on the suction, or at the suction holes of the rattlehead; also any air sucked in at the packing glands is caught. The air passes right through the pump casing and valves, and when the air-vessel is fixed in the correct place the air is trapped into it. The objection to this mode is that the pump draws a fraction less water, and the ram or bucket is apt to jump at the beginning of the stroke should there be more than a very small quantity of air in the casing at any one time. This tendency, of course, increases with the vertical height pumped; but I have seen this plan adopted on pumps having fifteen, twenty, forty, ninety, and one hundred fathoms of vertical head with good results.

Refer to Plate VI., Fig. 1., at *C*, for the third method. We have there a separate pipe or chamber *C*, fitted with a common stop cock *e*, a self-acting inlet valve *f*, a self-acting outlet valve *g*, with the pipe *h* from the column, and the pipe *i* to the air-vessel, also an air-cock *k*. To give the air-vessel one charge of air the following is the process adopted:—Shut *f*, open *e* and *k*, and, as soon as the water in *C* is all run off and *C* full of air, shut *k* and *e* and open *f*, the water from the column *B* will then enter *C*, and send all the air out into the air-vessel via *g i*. This process must be repeated as often as is necessary. The objection to this process is that it is not automatic, and requires to be done by the man in charge.

The process as shewn at *D*, Fig. 1., is, I consider, the best under all circumstances. The apparatus consist of a small chamber *D*, a self-acting air valve *l* opening inwards, a self-acting outlet valve *m*, and a pipe *n* which leads the air into

the air-vessel. The chamber *D* is either fixed direct on to the pump casing *P*, or a pipe may be led from *D* to *P*, and thus *D* can be placed in any convenient position out of the way. The valve *l* opens automatically during the suction stroke of the pump, a small quantity of air is thereby drawn into *D*, and during the forcing stroke of the pump that air is expelled from *D* via *m n* into the air-vessel, and the same takes place every stroke that the pump makes.

The last method is by means of a small air-pump, either worked by hand or, which is much better, by some moving part of the pump. This action is familiar to every one, and need not be described.

To enable the man in charge to know how much air is in the air-vessel at any time, every air-vessel should be provided with a gauge-glass, the same as that used on a steam boiler, only with a longer glass tube; or a vertical row of pet cocks, so that by opening one of these either air or water would be let out, and so by trying cock after cock the correct position of the air could be ascertained. Without these, however, where there is much action on the air, the air gets warm and the walls of the part of the air-vessel that is occupied by air also gets warm, and where the ordinary pipes are damp that part of the air-vessel will remain dry. Thus the position of the air is roughly ascertained.

I will now offer the following observations which are readily suggested by what has been already said. Every pump which has the ram or bucket moving at a greater velocity than forty feet per minute, and has the area of the pipes not larger than the ram or bucket, will work sweeter with an air-vessel than without one. By having an air-vessel or air-vessels on the pump and on the pipes a greater velocity can be attained with the ram or bucket with the same degree of safety, and so the capacity of the pump is increased; or, if that is not required, less metal may be put into the pumps and pipes, and so the price of the fitting reduced.

Regarding the position of the air-vessel, the nearer it is to the casing or barrel the better. If only one is used, it should be placed immediately above the discharged clack—that is, on the delivery side of it. Then if the column be extra long, as in

pumping up an incline or any other road where a long discharge column is required, a number of air-vessels might be fixed; but the number of these, and the distance apart, will necessarily depend on the velocity of the water inside the pipes. It is quite evident that if a long distance intervenes between the ram, or bucket and the air-vessel, the shocks which have their origin in the casing or barrel will not be so readily relieved by the air-vessel as if a short space intervened; because there will be a greater body of water to move, the inertia of which will be sufficient to create a considerable pressure, though by no means so great as there would be if no air-vessel were there at all, unless we imagine some extreme case, as a pump getting suddenly totally fast at the foot, and dropping full stroke, when, of course, nothing could save the casing or barrel. If these conditions presented themselves to a moderate extent, I believe a piston air-vessel, as shown in Plate No. XI., would be of good service. Its action will be described further on.

It is also of vital importance to place the air-vessel in such a position that a regular supply of air may find its way into it and thereby replace the air that leaks away with the water, else a few days will be long enough to totally exhaust the air and leave the action of the air-vessel nil. Further, I have seen them placed on the side of a vertical column, on the side of a horizontal column, and even on the under side of a horizontal column, with the air-vessel placed comfortably on the pavement five feet below the column. Unless fully equipped for separate charging, all these positions are wrong.

The best form of an air-vessel for a vertical column is that shewn on Fig. 1 at *A B*, where it can be charged naturally or otherwise. The rising column *A B* is increased in diameter and an inside pipe *a* brought down near to the bottom of the chamber, where is fixed a cup *b* which diverts all the particles of air flowing with the water into the chamber.

The simplest way to fix an air-vessel on a horizontal line of pipes is as shewn on Fig. 2, Plate VI., exactly on the top side of the pipes; care must be taken to give the air a rising road from the column into the air-vessel, because the air in a water pipe runs or lies along the top of the water pipe, just as hydrogen gas

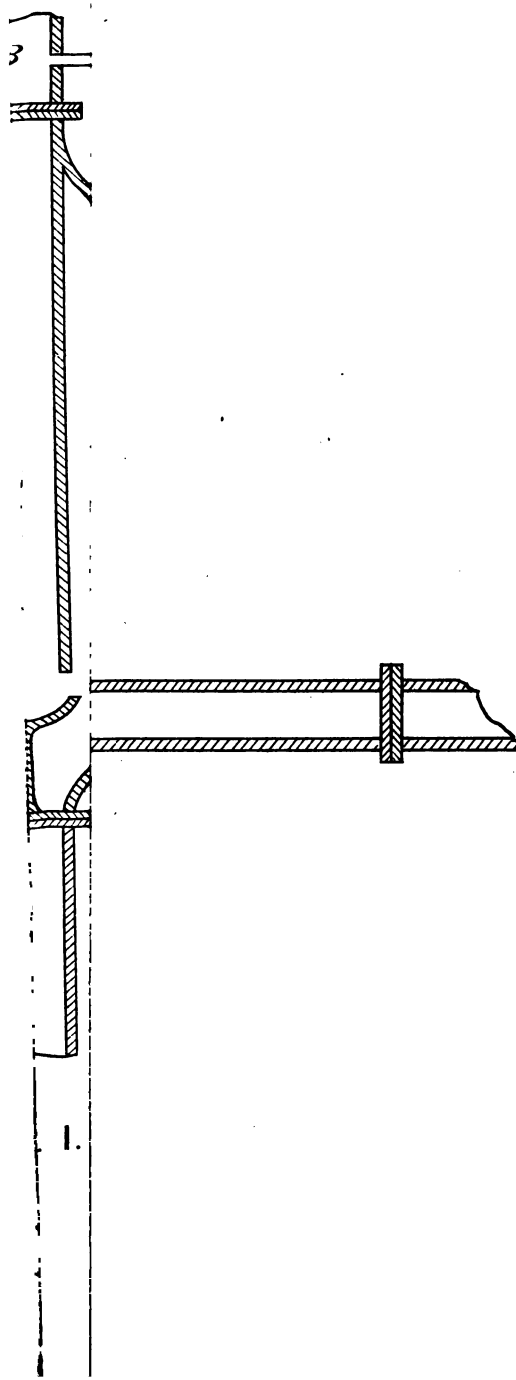
runs or lies along the roof of the mine. And where the line of pipes dips, before the air-vessel is reached, it is necessary to bridge over the dipping portion by means of a small air-pipe, the same as that shewn on Plate XII., and by so doing the water will flow much easier than where part of the area of the pipes is occupied by an accumulation of air; in fact, the presence of air in such a position is a sure source of trouble to the joints and the cause of serious shocks, and ought to be bridged over, whether there is an air-vessel or not.

Plate No. XI. shews a piston air-vessel, the same principle as that on our Moore's hydraulic surface power pump, but drawn so as to show its applicability to a single-acting pump. I consider it could be placed with much advantage on the casing or barrel of a plunger or bucket pump. It consists of a cylinder *a* into which is a piston *b*, which has direct communication on the under side with the casing or barrel *c*, and on the top side with the air-vessel *d*, there is also a connecting pipe *e* from below the piston to the top of the piston into which is fixed a self-acting valve *f*. This valve is constructed with a spiral spring on the top of it, so that it can be screwed down or eased off, so as to give the required pressure in the air-vessel. If the nominal pressure in the air-vessel is required at say 300 lbs., this valve *f* will be screwed down so that it will not pass any water unless the pressure in the air-vessel becomes less than 300 from leakage at the piston, the pressure in the air-vessel will thereby be sustained. It is also necessary to attach an air charger on this air-vessel. But the leakage of air is very slight. This piston air-vessel will act exactly the same as an ordinary one—that is, it will give and take each stroke of the pump, and has the great advantage of being close up to the place where, with few exceptions, all the shocks have their origin, that is, between the suction and discharge valves. Regarding the capacity of an air-vessel, I have made no investigations. The air-vessel on the Kelty pump shewn on Plate XII., and from which the diagram shewn on Fig. 9 was taken, is four times greater than the capacity of the ram. The one on the Pirnie pump, the diagrams of which are shewn on Figs. 3 and 4, is three times that of the ram. The one on the Pirnie pump, the

diagrams of which are shewn on Figs. 5 and 6, two times that of the ram. The suction air-vessel three-quarters that of the ram, and the piston air-vessel two times that of the ram.

I think, however, that no air-vessel should be of less than four times the capacity of the ram or bucket, and I believe that had the pumps referred to, whose air-vessel capacity is less than four times that of the ram, had greater air-vessels on, better results would have been shewn on the diagrams.

I would now place these observations on this interesting subject, before you, in the hope that they will stimulate discussion and further inquiry; and although they have been very hurriedly got up, and perhaps rather roughly expressed, I shall be very pleased if my hopes are realized and more light is thrown into my very imperfect knowledge of the matter.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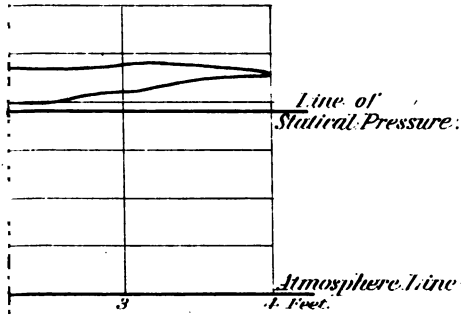

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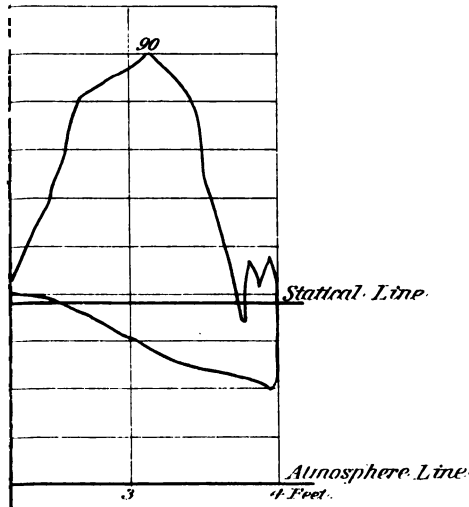

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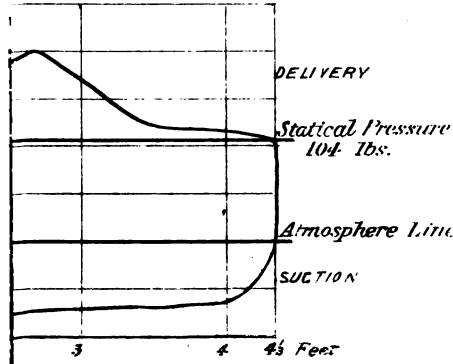

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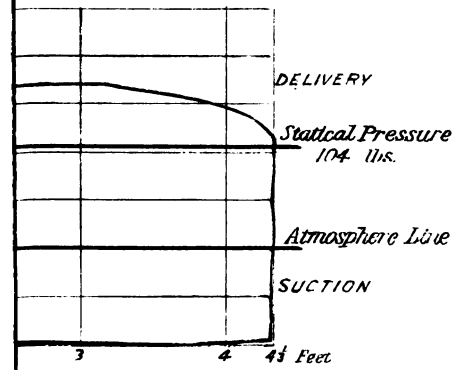

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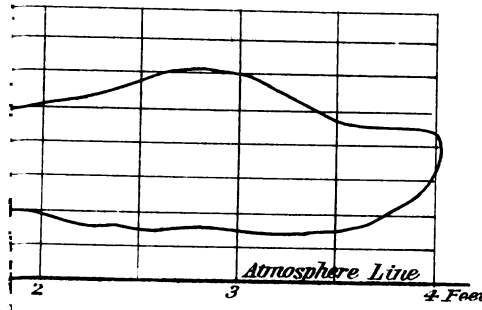
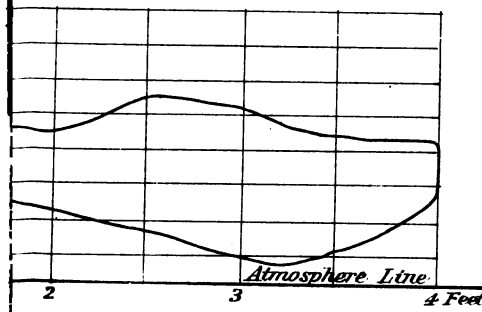


an Air-vessel.

Fig. 7.



Air-vessel.

Fig. 8.

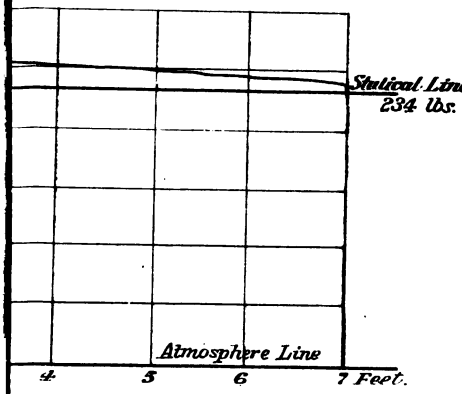


Fig. 9.

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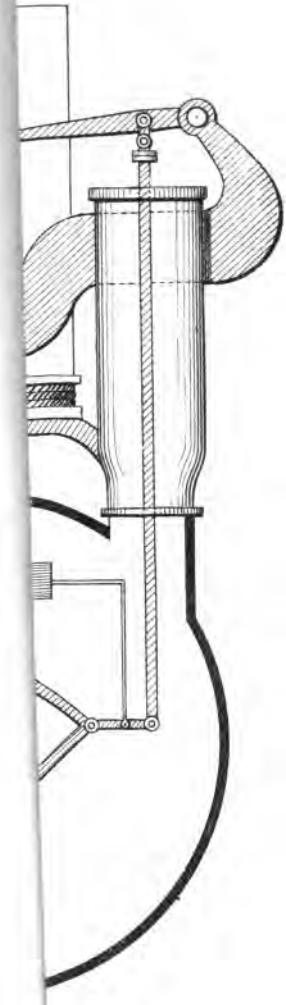

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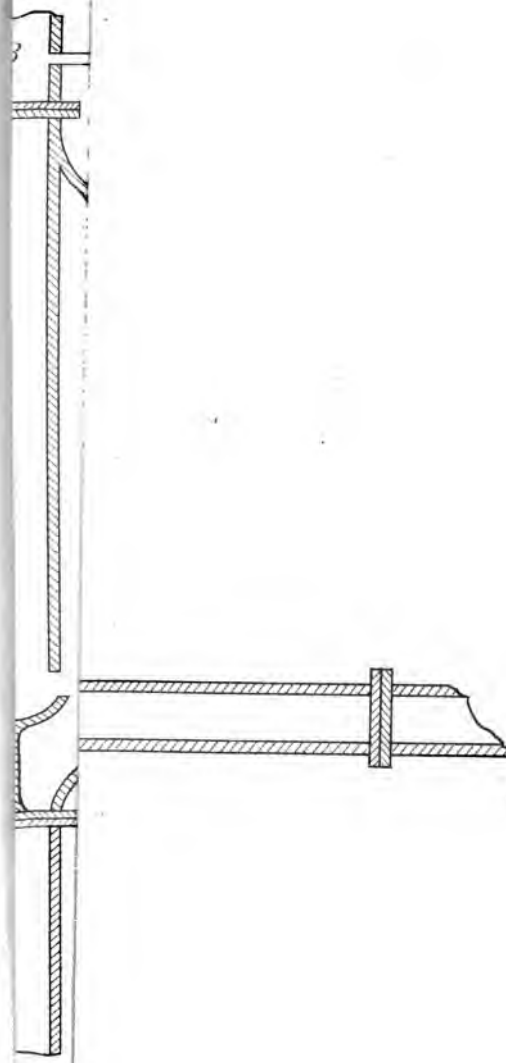

I.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW,

14th March, 1889.

JOHN M. RONALDSON, Esq., President, in the Chair.

The minutes of the last General Meeting were read by the Secretary and confirmed.

The following were elected by ballot as ordinary members :—

GEORGE RANKIN, Victoria Pit, Hurlet.
JOHN H. WALKER, Woodmuir Colliery, West Calder.
ROBERT WEIR, Grangemouth Colliery, Grangemouth.

The Secretary, on behalf of the Council, submitted a list of the members of Council who are eligible for re-election as office-bearers for the ensuing season, and thereafter office-bearers were nominated in terms of Sec. V. Art. 3 of the rules.

The following discussions then took place :—

DISCUSSION OF DR NASMYTH'S PAPER ON "THE AIR OF COAL MINES."

The SECRETARY read the following communication from Dr Le Neve Foster :—

Though the title of Dr Nasmyth's paper is "Report on the Air of Coal Mines," he introduces facts relating to ore mines which justify me in venturing upon some criticisms; besides which he has omitted to mention very important official statistics which bear upon questions which he discusses.

In the first place, Dr Nasmyth states that he has been unable to find any work on the air of mines published since the well-known volume *Air and Rain*, of Dr Angus Smith, 1872. I may be allowed to call his attention to three memoirs :—

1. *A. Schondorff*, "*Untersuchung der ausziehenden Wetterströme in den Steinkohlenbergwerken des Saarbeckens.*" *Zeitschrift für das Berg-Hütten- und Salinen-Wesen im Preussischen Staate*, vol. xxiv., p. 73.

2. *Cl. Winkler*, "*Die chemische Untersuchung der bei verschiedenen Steinkohlengruben Sachsens ausziehenden Wetterströme und ihre Ergebnisse.*" *Jahrbuch für das Berg- und Huttenwesen im Königreiche Sachsen auf das Jahr*, 1882. *p.* 65.

3. *Hesse und Menzel*, "*Untersuchungen über die klimatischen Verhältnisse in den Steinkohlenwerken des Zwickauer Reviers.*" *Ibidem*, p. 85.

Secondly—Dr Angus Smith's figures cannot fairly be taken as representing the condition of the air of collieries in 1863, because his analyses, with few exceptions, refer to ore mines, and the averages quoted by Dr Nasmyth are based entirely upon results obtained at ore mines.

Thirdly—After saying that Dr Angus Smith found on an average 0·785 per cent. of carbonic acid gas in the air of mines, he adds: "No miner at the present time would be asked to work in such an atmosphere, nor would he if asked." In my official report for 1884 (Reports of H.M. Inspectors of Mines for the year 1884—p. 213), I stated that I had made 170 determinations of carbonic acid by Hesse's method, and that in certain kinds of working places I frequently found from 0·5 to 0·8 per cent. by volume of carbonic acid. In my report for the following year

(p. 221) I described a case in which men were allowed to work for three months in places where the air contained from 0·8 to 1·2 per cent. of carbonic acid. My notices were unavailing, and the magistrates dismissed the case, when I prosecuted the owners for a breach of the first general rule under the Metalliferous Mines Regulation Act, which simply says that the amount of ventilation shall be *adequate*, without laying down any standard by which the adequacy can be measured.

Fourthly—In giving his opinion concerning the collier's occupation, possibly Dr Nasmyth had not before him Dr Ogle's report * upon the mortality in England and Wales during the ten years, 1871-80, a work of the highest importance, which will be particularly interesting to him, as it confirms his opinion that colliers have a decidedly healthy occupation and a low mortality from phthisis. On the other hand, it contradicts his statement: "I know of no disease peculiar to miners, or any disease in excess existing among miners;" for Dr Ogle says (p. l.): "It must, therefore, be admitted that coal miners, in spite of their being picked men, and in contrast with their low mortality from other diseases, suffer from diseases of the respiratory organs to a greater extent than those engaged in most other industries." Unless Dr Nasmyth intends the word "miner" to refer solely to *coal* miners, one must not pass over in silence the terrible mortality from disease among Cornish tin miners. Dr Ogle shows (pp. xxvi. and liv.) that the Cornish miner has the most unhealthy trade, with three exceptions, out of 94 occupations which he quotes; and I have shown on several occasions that the death-rate of Cornish miners from accidents is higher than that of colliers.

Lastly—Dr Nasmyth does not allude to the subject of coal dust and its possible protective influence against phthisis. Dr Ogle does not consider it proved beyond doubt (p. li.) that the low mortality from phthisis is due to the inhalation of coal dust; but Dr Hirt,† in a work written eight years later than the one quoted by Dr Ogle, adheres more firmly than ever to the opinion that it has a prophylactic action.

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* Supplement to the Forty-Fifth Annual Report of the Registrar General of Births, Deaths, and Marriages in England. London, 1885.

† "Arbeiter- Schutz." By Dr L. Hirt, Leipsic, 1879, p. 19.

Mr J. B. ATKINSON said he had looked over the table commencing on p. 179, shewing the wet and dry bulb temperatures; there seemed to be a good many inaccuracies in it. In two cases, he observed that the wet bulb was higher than the dry bulb, shewing that the instrument used had probably been inaccurate. All these observations only went to show that the mine in which they were taken was a damp mine, and if similar observations were extended to all classes of mines in Scotland that would be very interesting. In the report on Coal in the year 1870 by the Royal Commission, there were some of the best tables on the state of the air in mines as regarded dryness. He thought Dr Foster did not refer to that in his communication.

The PRESIDENT, in closing this discussion, said they were all very much indebted to Dr Nasmyth for the manner in which he had brought this subject before them. He did not think he pretended to be one who was conversant with everything, but he just brought before them what came under his notice in the mining district in which he resided. He thought the least they could do was to give Dr Nasmyth a hearty vote of thanks for his paper. (Cheers.)

DISCUSSION OF MR HUGH JOHNSTONE'S PAPER ON "LONGWALL WORKING IN THE EDGE SEAMS AT NIDDRIE COLLIERIES."

Mr R. T. MOORE said he did not know if it was necessary for him to make any reply to Mr Johnstone's remarks at a previous meeting. What he said was that at a meeting of the Benhar shareholders he told the chairman it would be better to work the coal at Niddrie by longwall instead of the method in operation, viz., stoop and-room. The chairman said it was impracticable, because it would cost so much, and they were not entitled to work the gas coal without also working the ordinary coal in the seam. He felt so strongly that longwall was the right

way that he wrote a report, and recommended the chairman to work the gas coal by longwall. He was much pleased to find the directors had adopted the longwall method.

The PRESIDENT closed the discussion of the paper, and moved a hearty vote of thanks to Mr Johnstone for his valuable contribution to their Transactions. (Cheers.)

The following communication was received from Mr Robert Beith after the meeting :—

The draws (not spouts) are carried up in the gas coal working here at Loanhead to the full dip and rise of the workings. They are driven 4 feet wide, and are causewayed in the bottom, and built on both sides with "clod," taken out of the working face. The "clod" is a strong grey fake, and stands well when the weight comes on. Our lifts are about 25 fathoms long, and the draws stand well all that distance. There is no difficulty in keeping them. Sometimes when we get up through to the waste we make a travelling road of some of our draws, for communication from the one bottom to the other. The first thing to fail is the pavement. It begins to heave up; but, as already stated, this does not trouble us at all. In working out our lift of 25 fathoms there is no difficulty whatever with it. It is afterwards, when it stands for some time after the lift is wrought out. It is eight years since this system was adopted, and it is working very well. By the Niddrie system they have all the drawing roads to keep open, whereas, with our system, we have only the levels to contend with; and again, the Niddrie people will use far more pillar-wood than we do, because every road they have must be built of pillar-wood on the rise side of the road, whereas, with our system, we have only the rise side of the level to build with pillar-wood. The "clod" from the workings builds the "draws." I may say, as the Niddrie people cut off their side roads with *brakes* every 100 fathoms or so, we also cut off our parrot levels every 80 fathoms or so with a cross cut mine from the Great seam.

Mr JOHNSTONE replies as follows :—

Mr Beith appears to have overlooked the fact that there are two distinct methods of longwall working carried on at Niddrie. That in the inclined measures is in many respects identical with the method practised at Loanhead. I may state that I inspected the

Loanhead workings in April, 1884, with a view to ascertaining whether a similar method could be adopted at Niddrie, and received some very valuable hints from Mr Legat, who was then manager at the colliery, and who, I believe, introduced the system there. As is indicated on p. 214, the length of the spouts or shoots—that is, the distance between the levels—will depend wholly upon the nature of the coal, the nature of the material forming the packwalls of the spouts and the inclination of the seam. Experience at Niddrie has shown that the best results are obtained when the levels are from 16 to 20 fathoms apart. With regard to the amount of pillar-wood required, I would remind Mr Beith that in the inclined working at Niddrie only the levels are pillared, and that the drawing roads are laid off level course only in the vertical measures, where it would be impracticable to drop the coal down spouts at all.

DISCUSSION OF MR DAVID COWAN'S PAPER ON COAL-WASHING MACHINES.

The SECRETARY read the following communication from Mr Davies, Bishop Auckland, to Mr Cowan, and Mr Cowan's reply thereto :—

Mr DAVIES' letter—As I had the pleasure of meeting and showing you the Robinson washers at Binchester and Auckland Park, I take the liberty of addressing this letter to you. My attention has been called to your paper read before the members of the Mining Institute of Scotland on the 27th December, 1888, and I was much surprised at the statements therein contained. On page 234 of the Transactions, you enter the cost of washing by Robinson's washer at 1·48d per ton, whereas at the collieries specially named, viz., Binchester and Auckland Park, there are three machines working daily of the following capacity, 200, 300, and 400 tons respectively, with one man at

each machine, who is paid 3s 8d per shift of 11 hours, being 11s per day for washing 900 tons of dross, or equal to 0·146d per ton. Would you kindly say how you arrive at the cost of 1·48d per ton? Also, on page 235, you put the rubbish in the dross coal previous to washing at 27·23 per cent., and 8·24 per cent. of rubbish left in the washed dross coal. This statement is so palpable that I cannot help thinking you have been misled by some one, as the statement is not correct. We have no coal with 27 per cent of ash in it. The highest we have is 16 per cent., which is reduced from 2 to 3 per cent. All the washed dross is used for coke making. Any dross containing 7 per cent. of rubbish would not be used for coking until it was washed. Also your remark on page 231, namely, "and is in operation at Binchester, Auckland Park, and Black Boy Collieries, in the county of Durham, and at the Bothwell Pits of Messrs Baird of Gartsherrie," gives one to think there are no other collieries using these machines at the present time. I might inform you that there are machines working at present washing 8,800 tons of dross coal per day, and several in course of erection. I think it is only fair to Mr Robinson that you should bring these few remarks before the members of the Institute, or a wrong impression might be given, to the prejudice of the machine, which would be unfair.

Mr COWAN'S reply—I am favoured by yours of 7th inst., and note your remarks. It is very possible I have been misled. We all are apt to be. My only object is to get correct information; and I will esteem it a favour if you can at any time give me any further information in the direction in which I am inquiring. I have forwarded copy of your letter to the Secretary of the Mining Institute, in order that he may deal with it as he thinks proper; also copy of my letter to you.

Mr JAMES F. WALDIE—I regret that I was from home on the occasion of last discussion, and that pressure of business has prevented my going as fully into the questions raised by it as I should have liked to have done. On getting the Transactions containing Mr Cowan's paper, I sent samples of unwashed dross and dirt from the washer at Legbrannock to Mr C. M. Aikman, 183 St. Vincent Street, together with a copy of Mr Cowan's paper,

asking that he would analyse them as Mr Cowan had done; and the following is the result, reducing Mr Aikman's figures to the table given by Mr Cowan on page 235 :—

	1.	2.	3.	4.	5.	6.
Per cent., - -	40·30	5·30	35	12·47	47·47	87½

No. 7 and 8 columns of Mr Cowan's paper I am unable to follow, and Mr Cranston's reading of the third and fourth columns (per page 244) appears to me to be the correct one. The laboratory results got by Mr Aikman, however, do not at all tally with our actual experience in working—the quantity of dirt in the unwashed material being far more than we ever found in the bulk, and the coal in the rubbish being also more than tests of quantities at the pits give us. I fancy that this fact may to some extent explain the difference between the result Mr Cowan gives, and the actual working at Woodend, and with Robinson's washer as given by Messrs Cranston and Forgie. As to the dirt left in washed coal the only reliable test would, it appears to me, be that of a whole waggon load several times repeated, or the test of the washed material by buyers, which is perhaps still more conclusive. The machine at Legbrannock has now washed nearly 40,000 tons, with only some four or five complaints from customers of foreign material amongst the washed stuff of all sizes. With regard to both the first cost and working of the machine at Legbrannock, I see no cause to materially alter the figures given on page 151, vol. ix. of Transactions. In Mr Cowan's table of cost I would like to point out that it is hardly fair to charge against the different machines the loss of coal in dirt, as so much really depends on the nature of the dross under treatment. If the Committee which has been appointed could arrange to test each machine with the same dross, I feel sure the results would be so much more reliable that they would be worth the little extra trouble and cost of making them.

Mr Geo. A. Mitchell said he thought, from the discussion that had arisen from Mr Cowan's paper, especially after what Mr Waldie had just said, that it was impossible to arrive at a very definite conclusion regarding the qualities of the different machines from such experiments as Mr

Cowan had made. Even if these experiments were quite accurate, it was quite patent that there were so many different conditions in which washing machines might work that they could not rely on the experiments made. For instance, as some one—he thought it was Mr Gilchrist—pointed out, in many cases there were particles of coal sticking to shale or sclit, and the washing machine in doing its duty naturally rejected those; but, if they subjected the dirt to analysis, of course they would find there was a large proportion of coal left in the dirt, and the machine got blamed for really doing its duty. To get a perfectly accurate comparison, they would require to have different machines at work with exactly the same material, getting exactly the same attention, and it was impossible, or next to impossible to have such a state of matters. What they really must depend on was to observe the same machines working in as many different circumstances as possible, and what they were all pretty well agreed on was, that from such observations they would find that it was desirable to subdivide the dross as much as possible, consistent with cost. Of course, it was quite evident from Mr Cowan's figures that they might buy efficiency too dearly. He showed them that, compared with other machines, although the Coppee machine gave considerably better results, yet, reducing the matter to figures and taking the first cost into consideration, it was found that the actual net results, as far as the pockets of the coalmasters were concerned, were in favour of the other machines. After quoting the figures to show what the author of the paper brought out for the various machines, the speaker claimed that the comparison was in favour of the Bell or some cheap form of bash machine. It was perhaps fair to point out here that the Coppee machine was stated to have a capacity of 200 tons a day, and would probably wash that quantity, but that the the Bell machine, although spoken of as able to wash a like quantity, was not able to do so. Mr Cowan had made a mistake in this respect. Nevertheless, the illustration was sufficient to show that they might get an extra efficiency without an extra profit. It was well to remember in connection with this, that this Coppee machine was originally designed for washing dross on the Continent, where the

price obtained for the dross was perhaps three or four times as much as they could get here. What they ought to aim at was a machine that would unite with sufficient economy sufficiently good results, and he thought it would be found that for a good practical bash machine to wash 100 to 200 tons four tanks would be enough—two for dross over $\frac{3}{8}$ths of an inch, and the other two—Feldspar washers—for dross under $\frac{3}{8}$ths of an inch, the dross being divided for each tank and four different sizes of dross being obtained. There was no doubt the Feldspar arrangement was a good arrangement, and they would have better results with it in the way of saving small dross, which he thought had troubled every one who tried washing. The holes of the plates in the bash machines got larger with the working of the machine, and a good deal of the small went through with the water. Mr Gilchrist said he had been able to save it, and it would be interesting if he would tell them how. What they should try to do was to find out how little sub-division they could do with, and they should bear this in mind, viz., what they were washing, as a rule, was a non-caking dross of no great value. Perhaps 2s a ton was the highest value they could put on anything likely to be saved. If they were washing a caking dross possibly the best way was to grind it to as nearly as possible one size before washing, because it was not likely that any one washing what was *naturally* caking dross would be satisfied with *naturally* small. They would wish to coke more than small, and as grinding would be required, it would be as well to grind the coal all one size, and wash as much as possible without sub-division. One thing that had struck him was that the discussion seemed to shew that there was really no patent for washing at all. Mr Rowan had pointed out that the Robinson machine was invented many years ago, and that, therefore, there could not be any valid patent for it. The same might be said of the Coppee machine. Some time ago, he looked up the Patent List and found that a very elaborate specification had been drawn out for this machine claiming a great many improvements, but most of these he found had been patented many years before. The use of Feldspar for washing small dross seemed to be the only original point, but Mr Rowan had pointed out that this

was not a new point, but must be ascribed to Herr Luhrig. They might take it that there was no valid patent. Perhaps that might help them in their prospective investigations as to the best arrangement. Mr Cowan said in one part of his paper that he thought the Robinson machine might do very well for large dross but not so well for small dross. He was inclined to think he was putting it the contrary way, because from inquiries he had found that while it gave good results for small dross, there were cases where it did not give satisfactory results for large dross. In the table in Mr Cowan's paper, p. 236, the additions across were incorrect. In some cases he added the last two columns; in other cases the last three.

Mr JAMES GILCHRIST said in the letter from Mr Davies it was stated that only one man was required to attend each machine. but such a statement is surely a very misleading one. He has evidently overlooked the labour of taking away the rubbish that was washed out of the dross. He admits that they have 16 per per cent. of ash in the dross washed, but, supposing the rubbish washed out is only 10 per cent., then he has 20, 30, and 40 tons respectively, to remove to the dirt heap, and I am sure the most of you will agree with me that one man cannot attend to the machinery and remove so much rubbish. At Earnock Colliery they required one man, who did nothing else, to take away the dirt, and he had not far to take it, and the average quantity washed was much less than 200 tons.

The PRESIDENT said although Mr Cowan had received a good deal of adverse criticism, they were indebted to him for his paper. He had awakened their interest, and in a great measure prepared them for receiving a splendid report from the Committee when they came back with their note-books filled for their information. He asked them to accord a hearty vote of thanks to Mr Cowan for his paper. (Cheers.)

DISCUSSION ON MR DUGALD BAIRD'S PAPER ON "AIR VESSELS."

Mr BAIRD, in reply to the President, said he had very little to add to his paper. There were a few unimportant points he might refer to. In giving the velocity of the water inside the pipes, it was the average velocity he had mentioned. The maximum velocity was often as much as a half more than the average velocity owing to the time lost at the top and bottom of the stroke. That caused all the more friction and the greater necessity for air vessels. In describing the third method of charging the air vessels, the valve *f* was mentioned as self-acting. It was not so. That was a mistake of his. There was also a clerical error where the length of the suction was put down as the height, whereas immediately after the height of the suction was mentioned (page 254, line 20).

Mr JOHN SCOTT said :—I have read with much pleasure and profit this ably written paper on the important subject of "Air Vessels," by Mr Baird, and in a great measure concur with him in many of the conclusions drawn from his experiments. Some time ago, I made a few experiments similar to those conducted by Mr Baird in the drawing up of his paper. I then had a different object in view in the conducting of my experiments, which I may mention further on ; but as they have a direct bearing upon the air vessel question, I shall describe them, although they do not wholly support Mr Baird's position. The fitting in this case is a direct acting horizontal pumping engine with a cylinder 51 inches diameter and 6 feet stroke, driving direct a pair of bell-cranks giving the same stroke to two plunger pumps in a pit $59\frac{1}{6}$ fathoms deep, and divided into two lifts—namely, $36\frac{5}{6}$ fathoms for the top, and $22\frac{1}{3}$ fathoms for the bottom ; diameter of plunger in both lifts is 28 inches by 6 feet stroke, and discharging up 22 inch pipes in both cases. The head of water in the top lift is 221 feet, giving a statical pressure of 96lbs. per square inch, and I found on fixing a pressure gauge in the main column between the two clacks, when the engine was going at $4\frac{1}{2}$ strokes per minute, that it registered a pressure of 130lbs. per

square inch in opening the discharge valve, being an increase of $35\frac{5}{12}$ per cent. over the statical pressure; and the uniform pressure maintained throughout the stroke was 102lbs. per square inch, being an increase of $6\frac{1}{4}$ per cent. over the statical pressure. The same pump going at $2\frac{1}{2}$ strokes per minute, the statical pressure was 96lbs. per square inch as before. The pressure in opening the discharge valve was 110lbs. per square inch—equal to an increase of $14\frac{7}{12}$ per cent. over the statical pressure. The pressure maintained throughout the stroke was 100lbs. per square inch—equal to an increase of $4\frac{1}{6}$ per cent. over the statical pressure. Secondly.—In the bottom lift, the head of water is 134 feet, and on fixing the pressure gauge in the same position in the main column the statical pressure was 58lbs. per square inch. The pressure registered in opening the discharge valve was 95lbs. per square inch, being an increase of 64 per cent. over the statical pressure; and the uniform pressure maintained throughout the stroke was 62lbs. per square inch, showing an increase of $6\frac{26}{29}$ per cent., or nearly 7 per cent. over the statical pressure. Now, this ram going at $2\frac{1}{2}$ strokes per minute, the statical pressure was 58lbs. per square inch, and in opening the discharge valve 85lbs. per square inch, being an increase $46\frac{16}{29}$ per cent. over the statical pressure. The pressure maintained throughout the stroke 62lbs. per square inch—equal to an increase of $6\frac{26}{29}$, or nearly 7 per cent. over the statical pressure. When the engine is going at $2\frac{1}{2}$ strokes per minute, the piston and rams are travelling at a rate of 54 feet per minute, while the velocity of the water in the delivery pipes is 87 feet per minute. Now the only difference in the design or construction of these two pumps is that the first or top ram has no air vessel, while the last or bottom one has two air vessels, having a cushioning capacity of $2\frac{3}{4}$ times the capacity of the ram. In looking over and comparing the two rams, from the results of those experiments, if we adopt the plan that their respective merits lie in the small pressures indicated when working, then the first is by far the best, and it is the one having no air vessel.

TABLE OF COMPARISON.

	Going at 4½ Strokes per Minute.					Going at 2½ Strokes per Minute.				
		1.	2.	1.	2.		1.	2.	1.	2.
	Statical Pressure per Square Inch.	Pressure in Opening Discharge Valve.	Uniform Pressure throughout Stroke.	Percentage over Statical Pressure.	Percentage over Statical Pressure.	Statical Pressure per Square Inch.	Pressure in Opening Discharge Valve.	Uniform Pressure throughout Stroke.	Percentage over Statical Pressure.	Percentage over Statical Pressure.
	Lbs.	Lbs.	Lbs.			Lbs.	Lbs.	Lbs.		
Top Ram,	96	130	120	$35\frac{5}{12}$	$6\frac{1}{4}$	96	110	100	$14\frac{7}{12}$	$4\frac{1}{6}$
Bottom Ram,	58	95	62	64	$6\frac{26}{29}$	58	85	62	$46\frac{10}{29}$	$6\frac{26}{29}$

The PRESIDENT—Were the vessels working well?

Mr SCOTT—Yes; we had no reason to doubt them.

Mr RALPH MOORE said he thought Mr Scott referred to the Wilsontown engine with a fly-wheel, and, of course, the speeds were very different at different parts of the stroke. In the centre, they would have more, and that was the advantage Mr Baird spoke of. They would likely get the best results in a direct acting engine which starts slowly and in which the speed increases more gradually than in the crank engine. Hence, they would see in all Cornish engines, the first thing was the injection was put on, and that started the engine slowly. Then the steam valve opened, which brought up the speed, and they had possibly the least resistance from increased pressure. It naturally would follow that the speed would be slightly increased about the centre of the stroke because the engine had to stop, and the steam had to be shut of to allow this to be done slowly. Still, he thought, in a direct action engine, they would have a more uniform speed, and also the power of starting more easily. He could quite believe the results their friend had given them as to the want of the air vessel and with the air vessel. Still, to his mind, the advantages of an air vessel were very great, and he had always thought so. Another point was, it might be known to many of them, if a little air was let into the suction end of the pump, they would find the engine went very much

better. Of course, the engine on air would not work well, but a little air let in, he believed, was a very great advantage to the smooth working of the engine. He regarded Mr Baird's paper as a very creditable effort, and he would like to see more of these before the Institute, because such experiments were not known to everybody, and they were very useful. After all, it told them that the great thing was to have everything about pumps very strong. Perhaps in no case should the metal be strained beyond a thousand pounds on the square inch, and considerable care should be taken in the bends. They would see some people making a clack door without paying attention to the back part of the door, which was the weakest part. All that required to be attended to carefully.

The PRESIDENT said he thought one thing Mr Baird's paper taught was to have plenty of size in the discharge pipes. Probably many had noticed where pumps attached to the crosshead of winding engines were used to feed the boilers, owing to the high speed and sharp bends the pipes got a severe shock every stroke.

MR RALPH MOORE said he did not quite follow the President as to the advantages of large pipes. He thought pipes might be too large and might be very weak. He thought, unless they got the water travelling over 200 ft. a minute, they did not have very much pressure, and he thought where it could be arranged they should make their pipes much smaller and stronger, and there would be less risk of breakage.

The PRESIDENT said of course the pipes might be made too large, but he thought the great danger was in setting a body of water suddenly in motion, and he suspected that was where the shock came on. If it was gradually set in motion, instead of all at once, therein came the relief, and such an appliance as an air vessel gave this relief.

MR EASTON said he thought there was another point. The resistance increased as the square of the velocity, so if the pump was working at 54ft., the velocity was 150. It was nine times the resistance in that case, caused by friction and increased velocity.

Mr R. T. MOORE said he had had a good opportunity of experimenting in the sending of water through pipes at consider-

able velocity, and the conclusion he had come to was that so long as the velocity did not exceed 200 feet per minute, there was very little friction caused. The extra strains on the pipes were not caused by the friction of the water in passing through them. The friction of the water going at 200 ft. was not more than a head represented by one per cent. of the length of the pipes. The strains were due to the shocks caused by setting the water in motion. With an ordinary single acting pump the water had to be started and stopped every stroke. If they took a speed diagram of a pump driven by a geared engine, they would find at the starting of the stroke the increase of velocity was much greater than it would be if the velocity were caused by a constant pressure, such as would be got in a direct-acting pump where the pressure of the steam in the steam cylinder was directly against the pressure of water in the pump. They had more strain on the pipes. The benefit of an air vessel was specially found in that case, because, though the acceleration was much too high, the space through which the pump travels was a very small one, and a very little relief given to the pump took the shock off at once. Consequently, it was almost essential to get the best results, to have an air vessel on a fly-wheel pump. He should think the results Mr Scott mentioned with regard to the Wilsontown engine were very much due to the fact that there was very little air in the air vessel. If in charging it they took the air at atmospheric pressure, it would compress very much, and there was really very little air to act as a spring in the air vessel. Then, what he said about the velocity of water in pipes pointed to the great advantage of the air vessel. It enabled them to have smaller pipes than they would have had had there been none. In that way, a very great saving might be effected on the first cost. There was another point, viz., letting a little air in at the suction end. That made the pump go so much more smoothly, it got below the discharge valve, and was gradually compressed until the valve lifted.

Mr Scott said, referring to the remarks of Mr R. T. Moore, he had misunderstood him a little regarding those percentages. He had compared the shocks with the pump having the air vessel, and with that one without it. The shocks in working with the

air-vessel were 64 per cent. over the statical pressure, while in the pump working without the air-vessel the pressure indicated over the statical was only 35, showing that really the pump having no air-vessel had fewer shocks than the one with the air-vessel.

Mr R. T. MOORE said that was very possibly owing to the position in which the air-vessel was placed. What he wanted to bear out was that, unless some special means were taken to charge it, an air-vessel charged in the ordinary way was of very little use. Probably the reason why there was more shock with the air-vessel than without it was on account of that, or the engine might be running less smoothly. A little difference in the velocity of the engine also caused a great shock.

Mr SCOTT said he was quite prepared to admit that there might be something in the velocity and in the ordinary conditions, but so far as the designs of the pumps were concerned they were both made of the same pattern, and there could not be any difference there. He would like to mention that a great deal of this increased pressure shewn by those results of his was due largely to the sectional area of the valve in proportion to the ram—not in proportion to the pipes themselves, because the area of the discharge clack was only a third that of the area of the ram. Consequently, the velocity passing through the discharge clack must be three times that of the ram. Now, the velocity of the water in the pipes was not over a half more than the velocity of the ram itself so he was inclined to think that really there was more in the smallness of the area in the clack, and the form of the clack, than there was in the speed the engine might be going at.

The PRESIDENT—Were the clacks the same in both pumps ?

Mr SCOTT—Identically the same.

Mr HUGH JOHNSTONE, with reference to what Mr Baird had said as to velocity of the different pumps, said he should like to ask if the velocity was the total space through which the ram was travelling per minute, or the space through which it was travelling while forcing water. He would also point out that in the diagram, figure 4, the pressure line appeared to rise something like five inches before the pump turned a stroke. He

did not very well understand why that should be, and he wished to ask Mr Baird. Then as regards diagram, figures 5 and 6, he would like to ask if the pump was going at the same speed with the air-vessel and without it. And, further, what was the size of his suction pipes, and what were the arrangements for giving the pump its water freely? If the engine was getting its water freely, he did not see why he should have nine pounds of vacuum on the suction side of his pump. In reference to diagram No. 9, he referred to it as an illustration of the actual pressure required to lift the pump valves. The diagram showed an extra pressure at the beginning of the stroke of about thirty pounds per square inch. It seemed to him any ordinary valve should lift with less than this: and probably the high initial pressure shewn by the diagram was partly due to air getting into the pump, causing a shock at the beginning of the stroke. If Mr Baird could put in a note describing the different kinds of engines that worked the pumps it would be important, for there was a great deal in that. With a flywheel engine they would expect a greater shock than a direct acting or bull engine.

Mr D. M. MOWAT—I have read Mr Baird's paper with great pleasure, and have here a few notes on the effects of air-vessels, which may shed some additional light on the subject. A dock is divided into two lifts, each of which is 170 fms. long, and the water is pumped by two 6in. double-acting pumps, driven by the same rod, and actuated by an engine having a rotary motion. The piston and pump speed is 112ft. per min., the stroke being 4ft. At the top pump the statical pressure is 75lbs., and the highest pressure reached during the stroke is 78lbs., or 4 per cent extra. The bottom pump has a statical pressure of 102lbs., and the highest pressure attained during the stroke is 125lbs., or about 23 per cent. extra. The only difference between the two pumps, besides the difference in head, is that the discharge pipes in the top pump are all 6in. or upwards, while there are 28 fms. of 4in. pipes in the discharge of the lower pump. Each pump has an air-vessel capacity of about 24 cubic ft., the capacity of the pump being about 1·50 cubic ft. per double stroke. This appears to shew that the increased velocity of the water in the small pipes

has a considerable effect in increasing the pressure, but does not affect Mr R. T. Moore's statement, the velocity of the water being in this case not less than 252ft. per minute, even if the air-vessels act perfectly. Although the pressure was not measured in these pumps without air-vessels, there is no doubt that the air-vessels do good service, as when the air-vessels get filled with water, the pump goes very irregularly, and causes considerable shocks to the pump rods. With regard to the proper capacity of air-vessels, in a 7½in. single-acting pump, with a 4ft. stroke, the capacity of which is about 1·20 cubic ft. per stroke, there was a considerable improvement when the air-vessel capacity was increased from 12 to 20 cubic ft. In none of these cases is there any arrangement for charging the air-vessels, they being placed above the column and the usual method being to run off the column or slacken one of the receiving valve covers for a short time. Although outside of the question of air-vessels, I should like to ask Mr Baird if he uses any particular type of bucket in a double-acting pump with a large head.

Mr BAIRD, in replying to the discussion, said Mr Scott referred to a pumping engine with a fly-wheel, and brought out results in favour of pumps without the air-vessel. One of the most important things which he missed was the condition of the bucket.

Mr SCOTT—The plunger.

Mr BAIRD—In the case of the plunger, the condition of the clacks. If the clacks were working badly,—if they were passing much water, as often was the case,—then the pressure would be much less. The area of the clacks was certainly too small, but as they were the same in both cases that did not affect the particular statement. Mr Scott had brought no evidence to show whether there was any air in the air-vessel. He did not say what the arrangement was for charging the air-vessel. Perhaps it was a defective system. He had no evidence to show that there was a single particle of air in the air-vessel. If there was none, it would be exactly the same as if there was no air-vessel at all, because everything would be solid water then. He thought, in the absence of these facts, Mr Scott could not put forward his claim at all. With reference to Mr Johnstone's remarks, he had not considered how in figure No. 4

the pressure rose before the pump got to the end of the stroke, but he might state that the diagram was taken off the pump some five years ago, and was transferred exactly as the pump gave the diagram. That was to say, the pump itself drew the diagram and he could not say how it should have risen at that particular time. It was a compound form of the bucket pump. There was a ram attached to the bucket, and that enabled them to have smaller pipes than they would otherwise have required. Mr Johnstone next referred to diagrams 5 and 6, and asked if the velocity of the ram was the same in both cases when the air-vessel was off or on. Yes, the velocity was the same. He then asked how the ram got the water from the suction pipes. He (the speaker) might mention that there was a tail clack—that was to say, a clack down near the suction end, so as to enable the pump to keep its water when it did get it, so that when the engine stopped, the water would not go back. It was the case that between every stroke this clack shut, and they would see in the diagram it shut in the middle of the stroke. It was continually opening and shutting. Immediately the air-vessel was put on, this clack had another movement; it remained constantly open. Before the air vessel was put on they heard it click every time. After the air-vessel was put on, they could not hear it at all, shewing with the diagram that the water was constantly passing it, and was certainly a favourable arrangement. He had another case of an air-vessel being put to the suction end of a pump. He remembered distinctly at Kinneil they had two suctions on the same pump. They put a cock on to them both, and very soon found out which was the size for the water. They screwed down the cocks so as to make the resistance in both cases the same, and to cause sucking water in both. Before the air-vessel was put on, if they hearkened to these cocks, they heard the water rushing through at every stroke, and could count the strokes at the cocks, and immediately the air-vessel was put on they could not. The same thing occurred to him as to Mr Johnstone with regard to the diagrams, in looking at them. Had he been to draw a diagram on theory, he would have made the one without the air-vessel a greater vacuum than with it, but he took the diagram as it was printed by the pump. The next one

Mr Johnstone referred to was diagram No. 9, where the pressure rose very much more at the beginning than after a little bit. He accounted for that from the pressure required to lift the valve, and it stood to reason, if it had a smaller area presented to the ram, it must take a greater pressure to lift the valve. There was therefore an evil in having too broad a face for a valve. Referring to Mr Mowat's remarks as to dook pumps with air-vessels, he accounted for the state of matters described by his splendid volume of air-vessel. The greatest volume of the air-vessels mentioned in the paper was four times, whereas Mr Mowat had some up to 16 times, shewing he had ample volume of air-vessel. Of course, the condition of the clacks would perhaps account for the difference of the two cases, and in the absence of this information he could not give an opinion. He also asked if there was anything special in the bucket in the way of resisting a great pressure. He did not think it required a special kind of bucket. Any ordinary bucket would stand the pressure. Even 125 lbs. was not a severe pressure, and the ordinary leather ones would stand that. With a double-acting pump, he would put on double cup leathers.

Mr Scott said he sincerely trusted their friend Mr Baird was not going away with the opinion, from the remarks he had made and the results he had quoted, that he did not believe in air-vessels. There was nothing more distant from his mind, and he mentioned those points and those experiments so that he might be enlightened as to the means of getting over those difficulties. His own opinion was that the sectional area of the valve was at fault. The design of the valve was also at fault. He had shewn there, in other words, a kind of double-beat valve, in place of a valve with a full sectional area exposed. His own experience, and also a work he was reading just now by a brother of Mr Ralph Moore in San Francisco on his experience there, which had extended over many years, had in a great measure convinced him, and the conclusion he had come to was that there was a great deal in the design of the valve. There was also a great deal in the size of the section of the discharge pipe up to the discharge valve. He had lately had large experience in the carrying out of new designs placed

alongside others of older date where the conditions were identical, and yet he found they worked more smoothly with a larger sectional area. He had no doubt the results shewn by the experiments he had there were largely due to that. Mr Johnstone made a remark as to the pressure required to open a valve, and he said it took 30 lbs. to open the valve alone, shewing it required 64 per cent. more than the statical pressure to lift it, while the uniform pressure was only 4½ or 5 per cent. more than the statical.

Mr MOWAT—The pressure to open a valve is the pressure to overcome the inertia of the water.

Mr BAIRD, replying to Mr Johnstone's question as to the engines, said the first was the Kelty pump, being a rotary fly-wheel engine, geared 1 to 3, with wooden rods; the next exactly similar; the next was a hydraulic, double-acting, with a fly-wheel, engine gear 1 to 3½; the next was the one where the diagram showed the increase of pressure to left; the engine was a Davey's Compound Differential.

Mr RALPH MOORE—They are all rotary except one?

Mr BAIRD—Yes, except the Davey's Differential.

On the motion of the PRESIDENT, the discussion was closed, and a hearty vote of thanks given to Mr Baird for his paper.

The Mining Institute of Scotland.

1888-89.

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*Deceased.

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M'Laren, William, Orchards, Bellshill, - - - 1884
M'Lauchlan, J. D., 19 St. Ninian's Terrace, Morningside Drive, Edinburgh, - - - - - 1882
M'Nab, John, - - - - - - 1881
M'Naughton, James, 11 West Regent Street, Glasgow, - 1880
M'Pherson, Gilbert, jun., Stair, Ayrshire, - - - 1887

Marshall, R. A., 97 Bath Street, Glasgow, - - 1879
Miller, Thomas H., Vulcan Foundry, Coatbridge, - - 1885
Mitchell, George A., 67 West Nile Street, Glasgow, - 1881
Moffat, Peter, Mount Albion, Herberton, North Queensland, - - - - - - 1881
Moore, Robert T., 160 Hope Street, Glasgow (*Councillor*), 1880
Morison, John, Newbattle Collieries, Dalkeith (*Councillor*), 1879
Morton, James, Manor Park, Blairhill, Coatbridge, - 1880
Mungall, Henry, Cowdenbeath Collieries, Cowdenbeath, 1880
Munro, R. D., 141 Buchanan Street, Glasgow, - - 1883
Murdoch, Alexander, 11 West Regent Street, Glasgow, - 1886

Nasmyth, A. H., Donibristle Colliery, Crossgates, Fife, - 1880
Nasmyth, J. A., Donibristle Colliery, Crossgates, Fife, - 1883
Neilson, George, Summerlee Iron Works, Coatbridge, - 1880

Neilson, John, Summerlee Iron Works, Coatbridge, - 1883
Nimmo, John, 12 St. Giles Street, Edinburgh, - - 1885

Oki, Yoshitada, Takasima Colliery, Nagasaki, Japan, - 1887
Ormiston, A. R., Gartness Coal Coy., 19 Waterloo Street, Glasgow, - - - - - - 1880
Ormiston, James, Mount Vernon, Glasgow, - - 1880

Park, John, Stonelaw Colliery, Rutherglen, - - 1881
Paterson, A. G., Earl of Rosslyn's Collieries, Dysart, - 1886
Paterson, Rev. T. M. B., Ardenclutha, Hamilton, - - 1888
Paul, Fred. W., Hallside Steel Works, Newton, - - 1887
Paul, James, 7 Shandwick Place, Edinburgh, - - 1879
Penman, Robert, 377 Dalmarnock Road, Glasgow, - 1887
Pettigrew, Robert, 66 Flowerhill Street, Airdrie, - - 1881
Pickering, John, 54 West Regent Street, Glasgow, - 1883
Pratt, George, 29 Waterloo Street, Glasgow, - - 1879

Rankin, John, jun., Drumgray Colliery, Airdrie, - - 1881
Rankine, David, 75 West Nile Street, Glasgow, - - 1879
Reid, John, The Athenæum, Glasgow, - - - 1883
Reid, Joseph, 67 St. Enoch Square, Glasgow, - - 1887
Ritchie, Robert, Silver Queen Mines, Mount Zeehan, Trial Harbour, Tasmania, - - - - 1888
Robertson, David, 21 Pitt Street, Glasgow, - - 1880
Robertson, D. A. W., Clydeside House, Renfrew, - 1882
Robertson, Dr J. R. M., Clydeside House, Renfrew, - 1886
Robertson, William, 123 St. Vincent Street, Glasgow, - 1879
Ronaldson, J. H., 97 Pitt Street, Sydney, - - - 1879

Rowan, Fred. J., 121 West Regent Street, Glasgow (*Vice-President*), - - - - - - 1883

Roxburgh, Alexander, Alloa Coal Co., Alloa, - - 1880

Roy, William, Allan Park House, Stirling, - - 1879

Russell, Archibald, jun., Avongrange, Hamilton, - - 1882

Russell, George, Summerlee Iron Works, Coatbridge, - 1883

Russell, P. B., Newfield, Hamilton, - . - 1887

Russell, Robert, Coltness Iron Works, Newmains, - 1878

Scott, William, 20 Drummond Place, Edinburgh, - 1888

Sharp, Robert, Coatbridge, - - - - 1886

Smart, James, Balgreen, Hamilton (*Vice-President*), - 1879

Smith, Eustace, jun., St. Lawrence Ropery, Newcastle-on-Tyne, - - - - - - 1885

Smith, George W., Port Elizabeth, South Africa, - - 1883

Smith, James, Saracen Colliery, Possil, - - - 1884

*Spowart, Thomas, Broomhead, Dunfermline, - - 1881

Stafford, Thomas W., 1 Lea Road, Heaton Chapel, Stockport, 1885

Stevenson, Hugh, 21 Clyde Place, Glasgow, - - 1884

Stewart, Alex., Tharsis Mines, Huelva, Spain, - - 1879

Strain, Hugh, jun., Rigg Colliery, Airdrie, - - 1887

Terris, Henry, Clackmannan Colliery, Clackmannan, - 1880

Thomson, Alex., 112 Bath Street, Glasgow, - - 1880

Thomson, Charles, Calder Iron Works, Coatbridge, - 1879

Thomson, David, Craigderran House, Cardenden, - 1887

Thomson, Thomas, 38 New Row, Dunfermline, - - 1884

Thorneycroft, Wallace, Merryton Colliery, Hamilton (*Councillor*), - - - - - 1887

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* Deceased.

Thornton, Peter, Crofthead, Fauldhouse, - - - 1878
Todd, John, Wellshot, Kilsyth, - - - - 1888
Torrance, James W., 81 St. Vincent Street, Glasgow, - 1881
Tweedie, James A., 12 St. Andrew Square, Edinburgh, - 1887

Waldie, James F., 53 Waterloo Street, Glasgow, - - 1883
Walker, James, 66 Waterloo Street, Glasgow, - - 1883
Walker, James P., Dalmellington Iron Works, Ayrshire, - 1880
Walker, William H., Springwells Colliery, Airdrie, - 1880
Wallace, James, Wester Gartshore Colliery, Kirkintilloch, 1882
Watson, John, Earnock, Hamilton, - - - 1879
Watson, William, Bank Street, Coatbridge, - - 1886
Weir, Alexander, Pentland Oil Works, Loanhead, - 1881
Whitelaw, Thomas, Dalzell Colliery, Motherwell, - 1879
Whyte, Robert, Royal Exchange, Glasgow, - - 1887

* Williamson, John R., 12 St. Andrew Square, Edinburgh, 1882
Wilson, Andrew, Dalzell Estate Office, Motherwell, - 1880
Wilson, John, Alderston, Mid-Calder, - - - 1881
Wilson, John, 69 Great Clyde Street, Glasgow, - - 1879
Wood, James, 40 St. Enoch Square, Glasgow, - - 1880
Wylie, John, Clifton Iron Works, Coatbridge, - - 1883

Yates, Andrew, Grange Colliery, Kilmarnock, - - 1881
Young, John, Baljaffray Colliery, New Kilpatrick, - 1881
Young, Robert, 37 West George Street, Glasgow, - 1882
Young, Robert, Kinneil Iron Works, Bo'ness, - - 1888
Young, William, 204 Stobcross Street, Glasgow, - - 1885

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* Deceased.

ORDINARY MEMBERS.

Subscription, 10s 6d.

Addie, Alexander, 67 Johnston Street, Airdrie, - - 1888
Allan, John, Calder Iron Works, Coatbridge, - - 1881
Allan, William, Woodyett and Dennymill Mines, Denny, 1881
Allardice, James, Eastfield Colliery, Cambuslang, - 1881
Anderson, David, Cowdenbeath Colliery, Cowdenbeath, - 1881
Anderson, George, Gateside Colliery, Cambuslang, - 1880
Anderson, George, Ferniegair Colliery, Hamilton, - 1885
Anderson, James, Montgomerie Cottages, Newmains, - 1887
Anderson, John, Lochgelly Iron and Coal Coy., Lochgelly, 1880
Andrew, Robert, Minas de Aznacollar, Seville, Spain, - 1880
Andrew, William, Lassodie Colliery, Dunfermline, - 1880
Archibald, David, Banknock Colliery, Bonnybridge, - 1888
Archibald, William, Haywood Colliery, Lanark, - 1879
Arnott, Thomas, Clyde Cottage, Tollcross *(Councillor)*, - 1879

Baird, Dugald, Leven Collieries, Leven, - - - 1887
Baxter, Robert, Niddrie Collieries, Portobello, - - 1880
Beith, Robert, Loanhead Colliery, Loanhead, - - 1878
Benson, James R., West Longrigg, Airdrie, - - 1887
Beveridge, David, Kirkness Colliery, Lochgelly, - - 1888
Beveridge, James, Linlithgow Oil Coy., Linlithgow, - 1882
Beveridge, John, Kelty Colliery, Blairadam, - - 1881
Birrell, George, Townhill, Dunfermline, - - - 1880
Blackwood, James, Albany Place, Hamilton (*Librarian*), - 1887
Blyth, Archibald, Bent Colliery, Hamilton (*Treasurer*), - 1878

Bowie, Hunter, Lugar Iron Works, Old Cumnock, - 1881
Bowser, C. H., 13 Royal Crescent, Glasgow, - - 1885
Brown, George, Longriggend Colliery, Airdrie, - - 1880
Brown, James, Caledonian Cottage, Morningside, - - 1887
Brown, John, 43 Lowries Place, Duke Street, Hamilton, - 1887
Brown, John, - - - - - - 1888
Brown, Robert, Drumpellier Colliery, Coatbridge, - 1883
Brown, Peter, Martin's Crescent, Airdrie, - - - 1881
Brownlie, Archibald, Lassodie Colliery, Dunfermline, - 1883
Bryden, David, Coylton, Ayr, - - - - 1881
Buchanan, John, Calderbank Colliery, Airdrie, - - 1887
Burns, Daniel, Westburn Colliery, Newton, - - 1888
Burt, Hutchison, Fordell Colliery, Crossgates, Fifeshire, - 1885

Cairns, William, Muiredge Colliery, Buckhaven, - - 1887
Caldwell, James, Pumpherston, Mid-Calder, - - 1887
Campbell, Alexander, Bellfield Colliery, Hurlford, - 1882
Campbell, John, Cottages, Greengairs, Airdrie, - - 1888
Campbell, Thomas, Spindleside Colliery, Omoa, Motherwell, - - - - - - 1881
Carey, William, Grange Colliery, Bo'ness, - - 1882
Carmichael Robert, Earnock Colliery, Hamilton, - - 1880
Clarke, J. A., Ayr Colliery, Ayr, - - - - 1880
Clark, John, Arniston Colliery, Gorebridge, - - 1888
Clark, William, 208 St. Vincent Street, Glasgow, - 1883
Clelland, James, Carronhall Colliery, Falkirk, - - 1879
Cochrane, Joseph, Canadian Phosphates Coy., Buckingham, Quebec, - - - - - 1883

Cochrane, Neil, Glasgow Canadian Phosphates Coy. (Limited), Buckingham, Ottawa, Canada, - - 1881
Cowan, James, Cadzow Colliery, Hamilton, - - 1885
Cranston, David, Woodend Colliery, Armadale, - - 1880
Crichton, A. H., Hillside, Linlithgow, - - - 1880
Crockett, John D., Curran House, Dungannon, - - 1880
Crookston, Andrew, Wemyss Colliery, Dysart, Fife, - 1880
Crookston, Thomas, Lumphinnans, Cowdenbeath, - 1879
Cunninghame, Archibald, Eglinton Iron Co., Dalry, - 1881
Cuthbert, Robert, Gauchalland Colliery, Galston, - - 1881

Danks, Henry, Green Colliery, Wishaw, - - - 1880
Davies, William, Barncluith Colliery, Hamilton, - - 1887
Dewar, Peter, Braidwood Colliery, Carluke, - - 1878
Dewar, Robert, Harthill Colliery, Whitburn, - - 1881
Dewar, Thomas, Glencleland Colliery, Wishaw, - - 1881
Drinnan, John, Trowell Moor Colliery, Nottingham, - 1880
Drinnan, Walter, Shotts Iron Works, Shotts, - - 1888
Dron, Robert W., Earnock Colliery, Hamilton, - - 1888
Duncan, George, - - - - - - 1881
Dunsire, Andrew, Cameron Colliery, Windygates, - 1883

Easton, Alexander, 13 South Bridge Street, Bathgate, - 1883
Easton, Alexander, 1 Vicarfield Terrace, Cambuslang, - 1888

Falconer, Thomas, 40 Witch Road, Kilmarnock, - - 1880
Faulds, Alexander, Calderbank House, Mid Calder, - 1878
Ferguson, David, Cadzow Colliery, Hamilton, - . 1878
Ferguson, Duncan, Lochore and Capeldrae Collieries, Lochgelly, - - - - - - 1880

Ferguson, William, Byrehill Row, Kilwinning, - - 1887
Findlay, Hugh, 78 Hill Street, Kilmarnock, - - 1886
Fisher, Robert, Thorniehill, Crosshouse, Kilmarnock, - 1888
Forbes, Alexander, Allanton Colliery, Hamilton, - - 1885
French, John, Millcroft Cottage, Rutherglen Road, Glasgow, 1879
Frew, James, 5 Greenhill, Waterside, Ayr, - - 1887
Frew, William, Barncluith Colliery, Hamilton, - - 1887
Frew, William, Quarter Colliery, Hamilton, - - 1887
Fulton, David, Dalquharran, Maybole, - - - 1881

Gardner, Thomas, jun., Auldton Collieries, Dalserf, - 1881
Gavin, James, Udston Colliery, Hamilton, - - 1880
Gemmel, James, Newfield, Rutherglen, - - - 1878
Gibb, Robert, Daldowie Colliery, Broomhouse, - - 1887
Gibson, William K., Carron Wharves, 87-93 Lower E. Smithfield, London, E., - - - - 1886
Gilchrist, James, Earnock Colliery, Hamilton *(Councillor)*, 1878
Gilchrist, John, 2 Old Terrace, Muirkirk, - - - 1888
Gilmour, James, Duchray Colliery, Coylton, Ayr, - 1881
Goldie, James, Springhill Colliery, Shotts, - - 1887
Goodwin, George, Gun Place, Woodside Street, Coatbridge, 1885
Graham, Hugh, Shotts Iron Works, Shotts, - - 1888
Grahame, John, Glasgow Road, Muirkirk, - - 1887
Grant, John, Bog and Home Farm Collieries, Larkhall, - 1878
Grant, Robert, - - - - - - 1881
Grant, Robert, Stewart's Buildings, Uphall, - - 1888
Gray, David, Chapel Colliery, Newmains, - - 1885
Gray, John, Browniesside Colliery, Airdrie, - - 1885

Gray, William, Common Cottage, Auchinleck, - - 1880
Gray, William, Carfin Colliery (Dixon's), Motherwell, - 1885
Green, William, Galston Colliery, Galston, - - 1883
Greig, James, Arden Works, Airdrie, - - - 1887

Haddow, John, Arniston Colliery, Gorebridge, - - 1879
Hamilton, James, 208 St. Vincent Street, Glasgow, - 1883
Hamilton, James, Bulli P.O., Wollongong, New South Wales, 1883
Hamilton, John P., Umaria Coal Estate, Katni C.P., India, 1888
Hamilton, William, Fountain Place, Loanhead, - - 1888
Hardie, James, Hopetoun, Winchburgh, - - - 1882
Hart, John, Clyde Iron Works, Tollcross, - - - 1881
Hart, Robert, 37 Gateside Street, Largs, - - - 1887
Hastie, James, Greenfield Colliery, Hamilton (*Vice-President*), 1887
Hastie, William, Gilmilnscroft, Auchinleck, - - 1881
Henderson, Andrew, Gartsherrie Colliery, Coatbridge, - 1880
Henderson, William, Levenseat, Fauldhouse, - - 1884
Herd, Samuel, Balgonie, Markinch, - - - 1885
Herd, Thomas, Dunnikier Colliery, Kirkcaldy, - - 1880
Heron, James, Auldhouseburn Colliery, Muirkirk, - 1888
Hill, James, Dalmellington, - - - - 1880
Hillhouse, William, Bonnyton Cottage, Kilmarnock, - 1883
Hogg, James, Rochsoles Colliery, Airdrie, - - 1887
Hogg, John, North Motherwell Colliery, Motherwell, (*Councillor*), - - - - - 1878
Hogg, William, Carnmoor Cottage, Forth, by Lanark, - 1881
Howat, John T., Eglinton Iron Works, Kilwinning, - 1883
Howat, Robert M., Bardykes Colliery, Newton, - - 1886

Howat, William, Dunsyston Colliery, Clarkston, Airdrie, - 1886
Howat, William, Southrigg Colliery, Armadale, - - 1886
Hunter, Adam, Bourtreehill Colliery, Dreghorn, - - 1885
Hunter, A., Alloa Colliery, Alloa, - - - - 1880
Hunter, Andrew, Orbiston Colliery, Bellshill, - - 1878
Husband, John, Kirkwood Colliery, Coatbridge, - - 1881

Ireland, Thomas, Largoward, St. Andrews, - - 1881
Irvine, William, 7 Auchenstarry, Kilsyth, - - 1887
Jackson, Douglas, Ross Colliery, Hamilton, - - 1880
James, William, Fordell Colliery, Crossgates, Fife, - 1883
Jamieson, Alexander, Balgonie Colliery, Markinch, - 1878
Jamieson, William, Rosebank Cottage, Broxburn, - 1879
Jeffrey, William, Ladylands Colliery, Shotts, - - 1888
Johnstone, William, Coaltown of Wemyss, E. Wemyss, - 1888

Kennedy, Alexander, Broxburn Oil Works, Broxburn, - 1882
Kennedy, William, Whiteside Lane Cottage, Bathgate, - 1888
Kerr, Archibald, Barncluith Colliery, Hamilton, - - 1881
Kerr, Archibald, Bankend Colliery, Lesmahagow, - 1881
Kerr, Thomas, Meadowhead House, Craigneuk, Motherwell, 1888
Kerr, William, Barncluith Colliery, Hamilton, - - 1885
*King, Henry, Drumpellier Colliery, Coatbridge, - - 1887
Kirkwood, William, 17 Underwood Road, Paisley, - 1880
Knox, James, Allanton Colliery, Newmains, - - 1880

Lander, Francis, Brownlie Colliery, Carluke, - - 1885
Legat, A. S., Banknock Colliery, Bonnybridge, - - 1879

* Deceased.

Lindsay, Thomas J. Castlehill Iron Works, Carluke, - 1885
Lithgow, Thomas, Langbyres Colliery, Omoa, Motherwell, 1882
Livingstone, Archibald, Banknock Colliery, Bonnybridge, 1880
Love, John, Shottstown, Penicuik, - - - 1878
Love, John, Portland Iron Works, Hurlford, - - 1882
Love, William J., Shotts Iron Coy., Shotts, - - 1881

M'Beth, Peter, Callander Coal Co., Falkirk, - - 1879
M'Cann, Edward, 9 Westpans, Musselburgh, - - 1888
M'Culloch, John, Jawcraig Colliery, Slamannan, - - 1888
M'Culloch, William, Linkieburn House, Muirkirk, - 1881
M'Donald, John, Greenhill Colliery, Holytown, - - 1880
M'Farlane, Walter, Mossvale Cottage, Chryston, - - 1882
M'Gee, John, Tillicoultry Colliery, Tillicoultry, - - 1880
M'Gown, John, Gilmerton Colliery, Liberton, - - 1883
M'Gill, James, Pentland Oil Works, Loanhead, - - 1887
M'Kay, James, Roughrigg Colliery, Airdrie, - - 1880
M'Kenzie, Daniel, 81 Windmillhill, Motherwell, - - 1886
M'Kenzie, John, - - - - - - 1886
M'Neil, James, Glencleland House, Wishaw, - - 1878
M'Phail, James, Balbardie Colliery, Bathgate, - - 1884
M'Pherson, Gilbert, Holmes Colliery, Galston, - - 1881

Malcolm, James, Inkermann Works, Paisley, - - 1879
Marshall, John, Seymore House, Stevenston, Ayrshire, - 1888
Martin, Robert, Westburn Colliery, Newton, - - 1879
Martin, William, Douglas Park Colliery, Bellshill, - 1881
Mathie, James, Cornsilloch Colliery, Larkhall, - - 1879
Middleton, George, Westburn Colliery, Newton, - - 1886

Miller, John D., Langloan Iron Works, Coatbridge, - 1888
Millar, William, 80 High Street, Loanhead, - - 1883
Milligan, Peter, Cleland, - - - - - 1884
Moffat, James, Allanton Colliery, Hamilton, - - 1885
Moffat, James, 34 West-End Cottages, Loanhead, - 1888
Moodie, Thomas, Devon Colliery, Alloa, - - - 1881
Moore, Robert, Pumpherston, Mid-Calder, - - 1888
Morton, John, Bellfield Colliery, Hurlford, - - 1880
Morton, R. M., Ansonhill House, Crossgates, Fife, - 1879
Morton, William S., Skaterigg Colliery, Maryhill, - 1884
Mowat, David M., Summerlee Ironworks, Coatbridge, - 1886
Muir, Robert, Bog Colliery, Larkhall, - - - 1887
Muir, W. W., Coltness Colliery, Newmains, - - 1878
Munro, James, Quarter Collieries, Hamilton, - - 1879
Munro, Neil, Twechar, Kilsyth, - - - - 1886

Nasmyth, A., Donibristle, Colliery, Crossgates, Fife, - 1880
Neilson, Benjamin, Prestongrange Coal Coy., Prestonpans, 1880
Ness, Henry, Benarty Colliery, Blairadam, Kelty, - 1880
Nevill, Thomas W., 208 St. Vincent Street, Glasgow, - 1886
Nimmo, Thomas, Fauldhouse Colliery, Fauldhouse, - 1879
Nisbet, Andrew, Carfin Colliery, Motherwell, - - 1884
Nisbet, Henry, Marchbank Cottage, Bo'ness, - - 1888
Nivison, John, Dykehead Colliery, Larkhall, - - 1886

Orr, Thomas, Shotts Iron Coy.'s Polkemmet Works, Bathgate, - - - - - - 1881

Park, James, Wellhouse, Rutherglen, - - - 1883

Park, Joseph, Allanshaw Colliery, Hamilton, - - 1878
Parker, William, Ellismuir Colliery, Baillieston, - - 1887
Paterson, Hugh, Braidhurst Colliery, Motherwell, - 1881
Paterson, Thomas, 208 St. Vincent Street, Glasgow, - 1883
Paul, James, Law Colliery, Carluke, - - - 1881
Penman, James, Leven Collieries, Leven, - - - 1883
Phillips, John, Birkenshaw Colliery, Larkhall, - - 1880
Pitcairn, James S., Cranrigg Colliery, Shettleston, - 1885
Potts, Samuel, Greenfield Foundry, Hamilton, - - 1888
Powell, Evan, Pentland Oil Works, Loanhead, - - 1888
Prentice, James, Stanrigg Collieries, Airdrie (*Councillor*), - 1881
Prentice, Joseph, Addiewell Colliery, West Calder, - 1880
Prentice, Thomas, Brisdanehill, West Calder, - - 1879

Rankin, George, Dunlop Street, Nitshill, Hurlet, - - 1889
Rattray, Thomas, Lumphinnans Colliery, Cowdenbeath, - 1884
Ritchie, James, Gartness Colliery, Airdrie, - - 1885
Robertson, Alex., Benwhat, Dalmellington, - - 1880
Robertson, Archd., Bathville Colliery, Armadale, - - 1880
Robertson, David, Dalquharran Colliery, Maybole, - 1881
Robertson, James A., 54 Blacket Place, Edinburgh, - 1885
Robertson, John, Lanemark Colliery, New Cumnock, - 1880
Robertson, Richard, Victoria Place, Longriggend, Airdrie, 1887
Robson, Robert, Sydney Mines, Cape Breton, Nova Scotia, 1882
Rodger, Alexander L., Tharsis Mines, Huelva, Spain, - 1884
Rodger, William, Fergushill Colliery, Irvine, - - 1888
Rome, J. E., Loganlea, West Calder, - - - 1886
Rorison, John, Springhill Colliery, Kilmarnock, - - 1883
Ross, Michael, Eddlewood Colliery, Hamilton (*Councillor*),- 1878

Rowan, Donald, East Benhar Colliery, Fauldhouse, - 1884
Rowan, Henry, Gartgill Cottage, Bothwell, - - 1881
Roy, John, Weir Place, Castlecary, - - - 1888
Russell, Andrew, Dykehead, Shotts, - - - 1887
Russell, Charles, Harthill Colliery, Whitburn, - - 1886
Russell, W. S., Binnend Cottage, Burntisland, - - 1880

Salmond, James, 28 Portland Place, Hamilton, - - 1888
Scobie, William, Gilbertfield Colliery, Cambuslang, - 1881
Scott, John, Calder Iron Works, Coatbridge, - - 1879
Seggie, James, - - - - - - 1885
Semple, William, sen., Goatfoot Colliery, Galston, - 1881
Sharpe, George, Wilsontown Colliery, Lanark, - - 1881
Shearer, James, Mountcow Colliery, Salsburgh, Holytown, 1888
Shore, Wm. M., Kaitangata, Dunedin, New Zealand, - 1886
Smith, David, Dalmellington Iron Works, Ayr, - - 1885
Simpson, Dundas, Ellismuir Colliery, Baillieston, - 1879
Simpson, James, - - - - - - 1881
Simpson, Robert, Auchter House, Newmains, - - 1888
Smith, Daniel, 325 Kirk Road, Wishaw, - - - 1887
Smith, David L., Barr Colliery, Beith, - - - 1888
Smith, Hamilton, Cadzow Colliery, Hamilton, - - 1878
Smith, James, Hallhill Colliery, Baillieston, - - 1881
Smith, John, Cannock Lodge Colliery, Bloxwich, Staffordshire, - - - - - - 1878
Smith, John, Rosehall Colliery, Coatbridge, - - 1880
Sneddon, James B., 44 Stewartfield, Broxburn, - - 1886
Sneddon, Robert, Millpark Cottage, West Calder, - 1888
Somerville, William, Bothwellpark Colliery, Bellshill, - 1880

Speir, William, Balgonie Colliery, Thornton, - - 1888
Speirs, Adam, Westmains Cottage, Bathgate, - - 1888
Stark, Archd., Orchardhead Cottage, High Blantyre, - 1888
Stevenson, Wm., Aitken's Buildings, Rawyards, Airdrie, - 1888
Stewart, H., Tranent Colliery, Tranent, - - - 1881
Stewart, Robert, Legbrannock Collieries, Holytown, - 1883
Stirling, John, Bonnybridge, - - - - 1880
Swann, Hugh P., - - - - - - 1887

Telfer, Henry, Overtown Colliery, Wishaw, - - 1878
Thom, Archibald, Moresby Coal Coy., Whitehaven, - 1881
Thom, James R., Bothwell Collieries, Bothwell, - - 1887
Thomson, A. M'D., Raith Colliery, Cowdenbeath,- - 1880
Thomson, George, Dundonald Colliery, Lochgelly, - 1884
Thomson, James, Ross Street, Dunfermline, - - 1883
Thomson, John, Foulford Colliery, Cowdenbeath,- - 1888
Thomson, Richard, Easter Shirva, Kirkintilloch, - - 1878
Thomson, Thomas, Arnloss Cottage, Slamannan, - - 1879
Turner, William, Chapel Colliery, Newmains, - - 1881
Twaddle, William, Ferniegair, Hamilton, - - - 1878

Waddell, Alexander W., 37 Burnbank Gardens, Glasgow, 1883
Waddell, Robert, 2 Park Terrace, Paisley, - - 1880
Waldie, A. B., 25 Douglas Crescent, Edinburgh, - - 1885
Walker, David, Dalzell Colliery, Motherwell, - - 1880
Walker, David, jun., Bathville Collieries, Armadale, - 1884
Walker, George B., Tankersley Grange, Barnsley, - 1887
Walker, Robert, Bog Colliery, Larkhall, - - - 1881
Walker, William, Cadzow Colliery, Hamilton, - - 1887

Walker, William, Rigside Colliery, Douglas, - - 1880
Wardlaw, John, Garriongill Colliery, Wishaw, - - 1878
Wardlaw, Robert, Crofthead Colliery, Fauldhouse, - 1883
Wardrope, James, Ormiston Station Colliery, Ormiston, - 1887
Watt, Robert, Barncluith Colliery, Hamilton, - - 1887
Webster, David, Burdiehouse Lime Works, Edinburgh, - 1880
Weir, Robert, Seaview Cottage, Grangemouth, - - 1889
Weir, William, 33 Anderson St., Cambusnethan, Wishaw, 1884
White, James, Corsehill, Kilwinning, - - - 1885
Whiteside, John, Ballochmyle Colliery, Auchenleck, - 1888
Wilkie, William, South Arnloss Colliery, Slamannan, - 1885
Williams, W. H., Shag Point Colliery, Shag Point, Otago, N.Z., - - - - - - 1888
Williamson, James, Dunbeth Terrace, Coatbridge, - 1880
Williamson, William, 64 Beckford Street, Hamilton, - 1886
Wilson, James, Lanemark Colliery, New Cumnock, - 1880
Wilson, Robert, Longrigg Colliery, Slamannan, - - 1880
Wilson, Robert, Eastgrange Cottage, Dunfermline, - 1880
Wilson, William, Auchinraith Colliery, High Blantyre, - 1879
Wood, Thomas, Dalmeny, - - - - 1887
Wylie, James, Townhill Colliery, Dunfermline, - - 1880
Wyper, James, Townlands Colliery, Hamilton, - - 1880

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NOTES ON PAPERS IN TRANSACTIONS OF KINDRED SOCIETIES.

Transactions of the CHESTERFIELD and MIDLAND COUNTIES INSTITUTION of ENGINEERS.—Vol. XVI.

SAFETY LAMP TESTS.

By Prof. ARNOLD LUPTON.

APPARATUS devised by Mr. William Clifford for testing lamps under pressure was erected at the Neepsend Gas Works, Sheffield. It consisted of a wooden tube, 21 feet long by 12″ high by 5″ wide, having explosion relief doors on its top. Air was forced into the tube from a pipe, in which a centrifugal fan produced a pressure of 11 inches W.G., and gas at 6″ W G. was introduced by a 2″ pipe. The lamp to be tested was put into a wooden frame, which tightly fitted the testing tube, and forced the current to pass the restricted spaces on each side of the lamp, and through the lamp itself; and a pressure of 3″ W.G. could be maintained in the tube, and pressing against the lamp. There were also arrangements for the same test in ascending and descending currents. Some of the lamps were blown out by the air current alone—among these were the Davy and Gray's—but the pressure is not stated. Those not blown out were tested in horizontal, vertical ascending, and vertical descending explosive currents. In the horizontal test, the Clanny and Stephenson exploded in 22 to 25 seconds at a pressure of 0″·4 to 0″·5 W.G.; most of the Mueseler's also succumbed; and the bonneted Clanny failed after 5 seconds under a pressure of 2″·3 W.G. Evan Thomas's No. 7 lamp exploded, after an exposure of 3 minutes, in a vertical ascending current at a pressure of 1″·3 W·G.; and M'Kinless's gauzeless lamp failed in 2 minutes 4 seconds, in a descending current, at a pressure of 1″·9 W.G. Clifford's was the only lamp that withstood all the tests, which were so highly artificial that their practical value is not easily estimated.

J. G.

TRANSACTIONS OF THE MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS. Vol. XI., Parts xcii. and xciii.

HYDRO-CARBON EXPLOSIVES AND THEIR VALUE FOR MINING PURPOSES,

With a Report on a Series of Experiments with Roburite.

By GEORGE BLAKE WALKER, F.G.S.

THE explosives of practical use which are at present known may be roughly classed under (1) gunpowder or nitrate compounds; (2) nitro compounds; and (3) hydro-carbon compounds. [There is also a small class of chlorate powders not noticed by this author.]

1. In this class the oxygen required for the combustion of the powder is derived from nitrate of potash. The ingredients in gunpowder are merely mixed together mechanically.

2. In this group NO_2 (nitric peroxide) is the oxidising agent, and the explosives are more or less true chemical substitution compounds of NO_2 and organic bodies such as glycerine, cellulose, or phenol. From these we have tri-nitro-glycerine, commonly called nitro-glycerine; tri-nitro-cellulose, or gun cotton; and tri-nitro-phenol, or picric acid. Nitro-glycerine *mixed* with 25 per cent. of kieselguhr forms dynamite; with 75 per cent. saltpetre it forms carbon dynamite; whilst by dissolving gun cotton in varying proportions in it we have blasting gelatine and gelatine oil. From this latter again are made gelatine dynamite of different qualities by mixing with it saltpetre in different proportions.

3. In this class definite compounds derived from hydro-carbons are mixed with suitable oxidising agents.

Sprengel in England, and Designolles in France showed some years ago that the aromatic hydro-carbons, as they are called, could yield powerful explosives. They produced several, among which are said to have been a composition resembling *Sekurite* produced by Sprengel, and *Melinite* produced by Designolles. These compounds, however, ignited too readily by friction, or decomposed too readily, or were otherwise dangerous and unsuitable, besides producing flame. Several explosives, however, more recently produced, such as *Hellhoffite, Carbonite, Sekurite, and Roburite,* retain the explosive properties of these hydro-carbon compounds, but have been carefully built up in order to possess the qualities required for safe use in coal mining.

Hellhoffite is mainly a mixture of concentrated nitric acid with hydro-carbons or their nitro compounds, such as benzol or nitro-benzol.

Carbonite is the same substance with the addition of absorbent infusorial earth, as in the case of dynamite.

Sekurite is not very well known yet.

Roburite is derived from benzol by displacing three units of hydrogen by one of chlorine and two of nitric-peroxide, and is called a chlorodinitro-benzol. The oxidising agent, which is usually mixed with this substance, is ammonium-nitrate, and the degree of explosive force is regulated by the proportions used. The effect of the presence of chlorine, which is peculiar to roburite, appears to be that absorption of hygrometric moisture is prevented, the action of the explosive is intensified, and the resulting gaseous products extinguish flame. The following is the chemical statement of the composition and results of the complete ignition of roburite:—

$$C_6H_3, Cl, 2\,NO_2 + 9\,NH_4\,NO_3 = 6\,CO_2 + 19\,H_2O + 10\,N_2 + HCl,$$

the following being the corresponding molecular weights:—

202·5	+	720	=	264	+	342	+	280	+	36·5
(Chlorodinitro-benzol.)		(Ammonium nitrate.)		(Carbonic acid.)		(Water.)		(Nitrogen.)		(Hydro-chloric acid.)

A charge of 1543·2 grains or nearly ¼lb. would produce in a space of 4 yards each way, or 64 cubic yards, a proportion of carbonic acid equal to about ·034 per cent. of the air contained in that space.

According to Herr Georgi, the relative volumes of the resultant gases from dynamite, blasting gelatine, and roburite are as follows:—

Dynamite, 881.
Gelatine, 1200.
Roburite, 1400.

Compared with gunpowder, roburite has theoretically 9 times its force, but practically the effect is 4·1 as compared with gunpowder. Being granular in form and less concentrated than gelatine, roburite adapts itself to the forms of shot-holes and occupies more space relatively. For this reason also it does not shatter the coal in blasting. It is not

exploded by blows from a steam hammer or by the pressure of the wheels of a heavy locomotive when the roburite was spread on the rails. It can be burned on an open fire, and if wetted can be dried with safety and with no loss of power.

The principal drawback to its use is the necessity of using detonators containing mercuric fulminate to explode it. If the detonators do not produce the degree of heat adequate to the complete detonation of the whole charge, part will burn without exploding and thus lose useful effect.

The particulars of a number of experiments are given by Mr Walker and by Mr C. E. Rhodes in the discussion on this paper, all of which are worth careful study.

Loose gunpowder, coal dust, cotton wool saturated with benzoline, tow with paraffin oil, and explosive mixtures of gas and air escaped ignition when cartridges were fired in contact with them, under circumstances in which gunpowder produced serious results.

Underground, the various kinds of shots incidental to coal mining—including blown-out shots and "ripping" or "brushing" shots—were repeatedly fired at Wharncliffe Silkstone Colliery and Silksworth Colliery with favourable results. Mr Rhodes also fired some experimental shots in a quarry, and compared the results with equal weights of gunpowder, gelignite, and roburite. F. J. R.

The SCHOOL of MINES QUARTERLY.—Vol. IX.

SINKING A SHAFT THROUGH LOOSE MATERIAL.

By Mr. A. M'C. PARKER.

THIS paper gives a practical account of the method of sinking a diagonal shaft along the foot-wall of a lode lying at an angle of 72°, at the Tilly Foster Mine—particularly of that part of it which was sunk through loose material, which had accumulated in the opencast working above the first pillar or floor left for keeping apart the walls of the lode—and also of the details of the timbering necessary to be built on the foot-wall, in order to support the track, in the open portion between the solid floors. The pit was 8′ × 10′, and a hole was first dug in the debris as deep as possible, and a frame of 10″ round oak laid in the bottom; separating stulls 4′ long were placed on its top, and on these again another frame was laid, and so on to the surface. Spilling boards, 9″ × 2″, were then driven into the loose material outside the cap of the lowest set and inside the cap of the set next above, and the dirt excavated in the bottom until another frame 4′ further down could be laid, when another row of spilling boards were driven down outside it as before. The tops of the oak spilling boards were afterwards sawn off close under each set, and pressed back outside it, so that at the finish the shaft had a double lining of 2″ oak planks. The progress made was about a foot a day with a single shift of 5 men. J. G.

PROCEEDINGS OF THE CLEVELAND INSTITUTION OF ENGINEERS—SESSION 1886-87.

THE EFFECT OF DISSOCIATION ON COMBUSTION.

By Mr EDWARD CROWE.

THE author of this paper tackles with a difficult subject, but one of great importance in metallurgical operations. Most chemical compounds can be resolved into their elementary components by the application of heat; at a temperature of about 1000° C. water *begins* to decompose into its constituent gases Hydrogen and Oxygen, and the temperature may be raised until it is wholly converted into these gases. So long as this high temperature is maintained the gases cannot reunite. When a portion of the free

gases combine and raise the temperature of the whole above the superior limit of dissociation it is impossible for the remaining free gases to burn until the temperature falls. Many attempts have been made, and by different methods, to determine the temperature of complete dissociation, but as yet it is unknown.

It has been suggested that the length of a flame is governed at the rate at which air diffuses into its combustible gases, but it is found when sufficient air is introduced previous to ignition the flame remains practically of the same length as before. and Mr Crowe thinks that no theory except that of dissociation explains the fact, as only so much of the gases can burn as will raise the temperature of the whole to the dissociation point. The author also considers the area of the flame to be governed by the dissociation temperature of its gases, and it is also likely to be affected by the fact of the radiation of heat increasing rapidly as the temperature is increased—a substance at 1500° C. radiating 16 times as much heat as it does at 1000° C. It is quite possible, then, that a gas having a slightly higher dissociating temperature than another may burn with half the flame area.

By heating the gases previous to ignition the temperature of dissociation is obtained by the combustion of a smaller portion of the gases, and consequeutly there is an increase in the temperature of combustion.

Other theories have been advanced to account for the limitation of the temperature of combustion, and the author takes occasion to combat that advanced by M. M. Mallard and Le Chatelier founded on the increased specific heat of high temperature gases.

ON DYNAMOMETRIC MEASUREMENT.

By Mr R. H. Froude.

Some general information is given, but the paper is practically a description of the construction and action of an absorption dynamometer invented by Mr Froude's father for measuring the horse power of large ships, and which is applicable as well to the testing of small high-speed engines. It consists of a fan driven inside a casing which is filled with water. By an arrangement of channels and blades in the walls of the casing and of corresponding channels and blades on each side of the fan, a steady and considerable resistance is offered to rotation by fluid friction. The paper deals at length with the theory of the construction of the machine and its applications.

PRODUCTION AND USE OF WATER GAS.

By Mr A. Wilson.

The decomposition of steam in the presence of incandescent coke produces hydrogen and carbonic acid, and by continued contact with the heated coke the carbonic acid is converted into carbonic oxide. In America, where there is but little coal suitable for the direct manufacture of lighting gas, but immense fields of anthracite, it is natural to expect that attention should have been early given to the utilization of water gas, especially as the waste products of the petroleum industry were available for carburetting it, and so supplying light. According to the experiments of Andreae of Vienna, one kilo. of anthracite and one kilo. of petroleum produce one cubic metre of lighting gas of double the illuminating power of ordinary coal gas.

The paper treats fully of the theory of the production of water gas; of European water gas plant; of water gas for heating furnaces and boilers; and of incandescent lighting by its means—its high temperature flame heating to whiteness combs composed of magnesia rods, which emit a light rivalling, in some respects, the electric incandescent lamp. The combs, however, are very fragile, lasting only 100 hours, but they cost only 1½d each. The cost of lighting by this system is estimated at 6d to 7d per 1000 cub. feet. The gas having no smell, there is added to it some noxious naphtha to guard against the danger resulting from escape. Mr Wilson also deals with the cost of water gas plant, and the revenue to be derived therefrom. J. G.

TRANSACTIONS OF THE MANCHESTER GEOLOGICAL SOCIETY.
VOL. XIX.

THE PROGRESS OF MINING AND GEOLOGY.

By Mr JOSEPH DICKINSON.

THIS is the subject of Mr Dickinson's inaugural address at the opening of the fiftieth session of the society. He discourses of the strides made in geological science from the now almost forgotten Plutonian and Neptunian hypotheses of Hutton and Werner to the modern glacial theory of Ramsay; and notes the gradual elaboration of the nomenclature of the rocks by Lyell, Murchison, and others.

In mining, he begins with the book of Agricola, the "peasant," dated 1556, at which time no mean progress had been made in the art, and shows how it rose by the labours of Buddle, Spedding, and others: Speaks of the old-world ways of trying for gas with a naked candle; of burning it out by firing—practised in Lancashire as late as the year 1850; and of the determination of its amount from the colour of the steel mill sparks: Talks of the hot discussions anent "furnace paradox," "natural brattice," and "furnace limit," now long forgotten; and carefully notices the results arrived by at the numerous Select Committees and Royal Commissions which have been appointed in connection with mines during the present century; and the progress of legislation and the almost parallel diminution of accidents; and, in concluding, states that "waste in working, pointed out by the Coal Commission in 1871, has in some respects been remedied, but much remains yet to be done, and apparently still requires the legislative enactment which the Commission hesitated to suggest."

RICHMOND COALFIELD, VIRGINIA.

By Mr WILLIAM CLIFFORD.

COAL has been worked in this field since the commencement of the eighteenth century. It is 30 miles long by from 4 to 10 wide, and lies at the base of the "only oolitic rocks found in all the United States and Canada," which are deposited in a basin, 3000 feet in depth, scooped out of the granitic rock. There are several smaller basins on each side of the main field. The beds are thickest in the middle and thin out towards each side of the basin, and in some places the coal is separated from the fundamental granite by only two inches of shale. The coal is described as fatty and close caking, yielding from 45 to 70 per cent. fixed carbon, 25 to 40 per cent. volatile matters, and from 2 to 16 per cent. of ash. In the neighbourhood of bedded trap rocks, it is altered into what is called "natural coke," which is also worked. The system of mining is stoop and room, the pillars being "robbed," but not systematically removed, with the result that creeps are of common occurrence, the crushed coal feeding the gob fires which always follow in due time.

The colliers are for the most part negroes, but there is a sprinkling of English miners and Virginians. In the olden time, the refractory slave was sent to the pits, the colliery owner paying to the slave-holder £30 per annum, and contracting to feed and clothe the bondsman and give him a month's holidays at Christmas, but he was not responsible for the slave's value if killed. So the slave-owner insured his property—his black brother. The slave-miner was often put on piece-work and also laboured during his holiday, and, after satisfying the charge for his hire and expenses, whatever was left over he got to himself, and was thus enabled, in many cases, to work out his own freedom. The negro is said to make a good collier, but having been wiled north to take the place of men on strike, he has returned to his home again with an acquired taste for settling his disputes and grievances after the manner practised by civilised white folks. Checkweighmen are unknown, and the truck system pure and simple is stated to be in force everywhere. The paper is illustrated by five sheets of plans and sections. J. G.

Journal of the BRITISH SOCIETY of MINING STUDENTS.—Vol. X.

COLLIERY COST ACCOUNTS.

By Mr. HUGH BRAMWELL.

BEFORE beginning to build a house, to count the cost thereof is the recommendation of the highest authority. And to count the cost of production at collieries at frequent intervals might be recommended with no less wisdom. At some works, fortnightly or monthly cost sheets do not exist, and the cost of working can only be obtained from the general balance at the end of the year. Cost books are often supposed to show the economy of management, but, to take two adjoining collieries working the same seam, these books would not furnish the information as to which was the more cheaply worked, because the quality of the product—the amount of dross it contained, for example—does not always appear ; and, if different rates are paid to the miner for coal and for dross in each, a comparison can only be made by taking into consideration the relative selling values of coal and dross. Neither do cost books show the relative efficiency of the management of the same colliery at different times, because men's wages vary, the number of full-working days vary in any period ; and, besides, air courses, roads, machinery, and many things about a mine, may be allowed to fall out of repair to save money temporarily, and coal dear to work may be abandoned for a time : so that, altogether, colliery management is something that stands in need of being weighed as well as measured by the figures of a cost book.

Mr Bramwell's paper deals with the different ways of making up profit and loss accounts for short periods, whether founded on the actual output, on the total saleable mineral produced, on the saleable large coal produced (treating the dross as a bye-product), or on the actual sales (neglecting stocks altogether.)

THE STOWING OF GOAVES IN COAL WORKINGS WITH BLAST FURNACE SLAG.

By Mr. CHARLES Z. BUNNING.

AT the Gräfin Laura Colliery, in Upper Silesia, a large amount of coal had to be left to support the surface—the workings lying below a town, near to which were blast furnaces belonging to the same company as the mines. The seam was 6 yards in thickness, and lay at an inclination of 11 degrees, and not only the pillars but a considerable thickness of roof coal had to be left as well. Beginning at the lowest level, the pillars are worked off in dip and rise slices, and the slag, which is lowered into the workings by a self-acting incline starting near to the iron works, is tipped in from the rise as each slice is completed. The wood is all lost, as the roof requires to be supported until the stowing is put in. Nevertheless, the cost for this item has been reduced from 1s 7d to 10d per ton with slag filling, as the timber does not require to carry the weight for so long, and is consequently lighter. As the furnaces escape a heavy charge for binging the slag on the surface, they pay for transporting and stowing it in the working, the cost for which amounts to 6½d per ton. It was found that a cubic yard of goaf required ·62 cubic feet of block slag. As yet, the surface shows no sign of sinking.

At the neighbouring colliery of Königsgrube, where the circumstances were not so favourable, slag stowing was tried and abandoned.

At Felix Colliery, near Nience, in Poland, a seam varying from 7 to 14 yards in thickness, and lying at an angle of 26 to 42 degrees, is worked with slag filling in slices taken in ascending order. The slag in this case is got close to the mine.

J. G.

Proceedings of the SOUTH WALES INSTITUTE of ENGINEERS.—Vol. XV.

PORTABLE ELECTRIC SAFETY LAMP.

DURING the discussion on this important subject, among much opinion, some valuable experience was elicited. Mr Pitkin exhibited his secondary battery lamp with side light of from four to five candles, which would burn twelve to fifteen hours, and it was stated a lamp weighing 4lbs. would burn for ten hours; and Mr Urquhart produced a primary battery lamp which could also if necessary be charged by a dynamo, it weighed from 4lbs. to 4½lbs. and had a light of 1¼ candle power on the top. Its cost was from 25s to 30s and the expense of keeping it in repair and charging was from 3d to 4d per week.

Mr Wilkinson had used twenty-five of Swan's lamps, weighing 6lbs. each, and capable of burning for eighteen hours for three months, giving them out indiscriminately every morning to colliers and drawers, and after rough work for ten hours a day they were little the worse. The light was equal to twelve to fourteen ordinary lamps; they had no switch, and a boy could charge them with ease, and he thought the working cost including replacement would be 4½d per lamp per week. He was negotiating for the purchase of 3000 of them.

Mr W. W. Hood had experimented with half-a-dozen different kinds of electric lamps, including Swan's, and had adopted the Pitkin, of which he had forty or fifty in daily use. They had difficulty with the switch, and if it could be made so that the workmen could not put it too full, so as to break the filament, he thought it would be perfect. It would burn from fifteen to seventeen hours, but for only ten hours gave a really good light, and the price was two guineas each. He had tried the Schanschieff primary battery lamps, and found that they allowed both gas and liquid to escape. The light was little better than the ordinary lamp and the cost of working was heavy.

There was some difference of opinion as to whether primary or secondary batteries were best, and as to the position the light should occupy on the lamp, and considerable disparity in the views of members about the result of breaking an incandescent lamp in an atmosphere of explosive gas. Some recent experiments tended to show that the shock which broke the globe usually broke the filament also, and in that case there was no explosion. Mr Galloway, however, would not admit that in these experiments sufficient care had been taken to mix the gas and air together, and contended that at the moment of fracture the lamp was not in an explosive mixture at all. Assuming the glass part of an electric lamp capable of no more effectual protection than the glass of an ordinary lamp, it remains that the electric lamp in its present development is as much a safety lamp as the best air-fed safety lamp known.

ON DAMPING DUST IN MINES.

By Mr H. W. MARTIN.

THIS is principally a description of a method adopted at Dowlais Collieries for cooling the air and damping dust by means of a water spray in conjunction with compressed air. The water is got from a cistern in the shaft, and is used at a pressure of 90lbs. on the square inch, and the air at 45lbs. on the inch from the pipe to an air hauling engine. The compressed air is introduced into the water by a nozzle in the interior of a T couple forming the junction of the air and water pipes. The air is first turned on until it passes in a fine stream through a "sprayer," which may be the flattened end of a pipe, and the water cock is gradually opened until the necessary amount of spray is produced. It is stated that it can be made so fine that it is carried by the ventilating current into the crevices of the roof timbers as well as along the sides and floor. J. G.

Transactions of the NORTH of ENGLAND INSTITUTE of MINING and MECHANICAL ENGINEERS.—Vol. XXXVII., Part I.

THE PYRITES DEPOSITS IN THE PROVINCE OF HUELVA.

By Mr. JOHN ALLAN.

THIS paper covers the same ground as that by Mr. Alexander Hill (Transactions Mining Institute of Scotland, Vol. VII., Page 253.)

In Spain, the minerals belong to the Crown, which levies a tax of one per cent. on the ore raised. Any person, even a foreigner, may register a claim, which, after the lapse of a certain time, is laid off by the Government engineer, the "denouncer" expropriating the owner of the surface should he refuse to sell his land at a reasonable price; and the proprietor of the concession can allow his mine to remain unworked for any length of time. The smallest claim laid off contains about 12,000 square yards, for which the rent is only two dollars per annum, and a small original cost for marking off.

The ore is composed of iron pyrites intimately associated with copper pyrites—soft, white, with metallic lustre when hard and poor; dark green, granular, and earthy when soft and rich. The percentage of copper varies from 1 to 10, and 3 per cent. is about the average. The deposits occur in a zone of clay slate, dipping at an angle of 70 to 80 degrees, and the lodes, if such they may be called, lie parallel to the stratification, being lenticular in shape, and varying in length from 110 to 330 yards, and in breadth from a few feet to 150 yards. Some of the deposits take a boat-shaped form, and are entirely cut off in depth. The ore is usually divided by joints. Short descriptions are given of the lodes at the important mines of Rio Tinto, Tharsis, and Calanos, which, together with almost every mine in the province, had been more or less worked by the Romans, whose skill and enterprise were so great that, even at the present time, a mine bearing no marks of their presence is, as a rule, set down as valueless. Where the ore was rich, these ancient miners had worked large areas by a kind of longwall, packing the cavities from which the mineral had been excavated with sterile matter. These old workings are, however, a source of danger to the modern miners. After "The Decline and Fall of the Roman Empire," the mines remained practically closed till the formation of the Tharsis and Rio Tinto Companies in quite recent times.

The system of mining has been either by opencast or pillar and stall, removing by the latter method one-third of the ore, leaving the remaining two thirds sometimes in such a ruinous condition that it can can scarcely be got by opencasting. In the gigantic open-works of Rio Tinto and Tharsis, the over-burden is removed in successive lifts of from 26 to 40 feet in thickness, and the mineral afterwards attacked in benches of 33 feet in height, the material being either hauled through level tunnels, raised by incline planes, or drawn up vertical shafts; but the latter methods involve the pumping of water, which, however, is very light.

In pillar and stall working, mines are driven on different floors, the pillars on each floor being formed directly under those on the floor above, and the ore is raised by shafts, or dropped through winzes to a low level tunnel. In average pyrites, with rooms 13 feet square, the cost for labour, explosives, and repair of tools amounts to 2s 5d per ton.

By opencast, there is complete extraction of the ore, but the pillar and stall system —which, on account of the readiness with which ore may be got with a small capital, has been employed at every mine in the province—is a wasteful method. Recently, however, a more creditable plan of complete removal of the mineral, with packing or filling in, has been begun at the Tharsis mines.

Ore containing over 3 per cent. of copper is exported; the remainder, about 66 per cent. of the total, is treated on the spot—calcined, washed, and the copper precipitated by metallic iron.

The natives are, as a rule, good workmen—earning from 2s 11d to 3s 4d per day. Coal is imported, costing 25s per ton at the mines. Timber is scarce—native pine costing 34s and Baltic pine 46s per cubic yard. The Customs duties are high—coal being charged 3s 1½d and iron 15s per ton. J. G.

Transactions of the NORTH of ENGLAND INSTITUTE of MINING and MECHANICAL ENGINEERS.—Vol. XXXVII., Part 1.

NEW USES OF BORE-HOLES.

AMONG the "Abstracts of Foreign Papers" is a notice of one on the above subject from the *Colliery Engineer*, in which it is stated that bore-holes are used as rope, steam, and water ways in the anthracite regions of Pennsylvania. At Shenandoah Colliery the hauling engines and boilers are placed on the surface, more than a mile from the mine mouth, and the rope passes down an 8in. bore-hole, sunk forty fathoms, which is lined with a 5⅝in. tube, the space around the tube being filled with cement. Another 6in. hole has four lines of 2in. gas pipes put into it, the interstices being filled with cement, and these serve as speaking tubes and for the passage of the signal wires. At East Franklin Colliery, two 8in. holes, drilled seven feet apart, similarly cased and cemented, are sunk one hundred and twenty-seven fathoms, and down these pass the hauling ropes for working a double roadway. At Meadowbank Colliery. a 12in. hole, cased with an 8in. pipe, and cemented, serves as the rising main for an underground pump. steam being led to it down an 8in. hole lined with a 5⅝in. pipe, and this also supplies a pair of hauling engines placed inside the workings. J. G.

Transactions of the AMERICAN INSTITUTE of MINING ENGINEERS. July, 1887.

THE KAIPING COAL MINE, NORTH CHINA.

THIS is a report by Kwong Yung Kwang, engineer at the mine, and if it be a fair sample of Chinese collieries, European engineers may have something to learn from the practice of their Celestial brethren.

The field contains nine workable seams, varying from two to thirty-five feet in thickness, and dipping at an angle of forty-five degrees. Two shafts are sunk, the one fifty and the other ninety-two fathoms deep, from which crosscuts are driven intersecting the various seams. In each seam, from the level of the one pit to that of the other, winzes are driven up every fifty feet. The working places are one hundred feet in length, and after leaving twenty feet for a pillar on the lower level, the remainder is worked uphill by longwall, the coal being sent down the middle winze in shutes or coal-boxes to the low level, where it is filled into hutches. Packing, which is quarried on the surface, is tipped from the upper level into the two side winzes, and with this all the waste is completely stowed. Sending the coal down these shutes reduces it to dust, but the natives prefer it in that form, and when lump coal is required self-acting inclines are used. In working the thirty-five feet seam it is divided into five slices, parallel to the stratification, each slice being worked off in ascending order like a distinct seam of seven feet in thickness, and having for its floor the stowage of the slice below. Very little timber is required, and the surface is of course preserved intact.

The total output is nine hundred and fifty tons daily, drawn in two shifts. The mine is drained by two of Davey's differential compound engines, cylinders fifty inch low pressure and thirty inch high pressure, and the workings are ventilated by a thirty feet Guibal fan.

Last year the large number of thirteen men was killed in the colliery, the accidents being due to falls and the tumbling of men down these steep inclines and shutes, and to blasting and dust explosions.

The miners are stated to belong to the lowest grade of society, and although ignorant are obedient. They are also somewhat superstitious, and do not regard the adage that "cleanliness is next to godliness;" and, among other more remarkable traits, stealing is by them considered a virtue not to be parted with, although they are fined in the value of the article and the offence impressed on their memory by the application of one hundred blows to their backs when caught in the act of pilfering. J. G.

Transactions of the NORTH of ENGLAND INSTITUTE of MINING and MECHANICAL ENGINEERS. Vol. XXXVIII.

A MINERS' SAFETY LAMP TO MEET REQUIREMENTS OF THE MINES REGULATION ACT, 1888.

By EMERSON BAINBRIDGE. P. 75.

SOME years ago the author described a new form of safety lamp, which has since been in use, but does not in its original form stand the tests now applied. Working from this lamp, another has been produced embodying the inventor's ideas in simplicity of construction, economy in first cost, in repairs, and in oil, facility in cleaning, and satisfactory illuminating power. Using oil, the cost of lamp keeping, including everything, is said to be 15s per annum, whereas burning spirit it is not over 10s. The new lamp is expected still further to lower the cost to 7s 6d per annum. The principal features are that it is formed of only four movable parts instead of ten, as in the case of some recently introduced lamps. The oil vessel is specially strong, and covered inside with tin, and is fed through the wick hole, preferrably with spirit, but oils may be used if preferred. The glass is longer by ¾ inch than usual, of specially clear quality, properly annealed. It may be cleaned in its place, and provision is made for expansion by heat. The shield is screwed to the glass frame, and is secured by the locking of the lamp. The cap of the gauze is a copper plate in place of the usual gauze cap. The light can be extinguished by closing the inlet holes with a movement of 3-16 of an inch; and it is perfectly safe in an explosive current at a velocity of thirty feet per second. The cost of the lamp is not more than 6s.

THE ENDLESS CHAIN IN SPAIN.

By GEORGE LEE. P. 81.

To convey the iron ore from the mines to the public railway, a distance of 3408 yards with a descent of 1640 feet, an endless chain road was established in seven lengths to suit the angles and intermediate mines. The maximum inclination, 1 in 2·3; and the average of the whole, 1 in 6·2. The tightening of the chain required to take up wear or to allow for variation of length due to varying temperature is effected by the terminal pulley being moveable in a frame by means of a screw. Concave curves occur in the section of the road, and at these points the chain is prevented from leaving the fork on the tubs by a see-saw arrangement of bearing-down sheaves fixed to a beam frame moveable round its centre on a horizontal bar over the tubs. "In each end of the beam is "placed a sheave on the line of the chain it bears down; beneath the sheaves the sides "of the beam, shod with iron, are deeper than the intervening space between, in the "middle of the beam which, when in a horizontal position, is free above the top of the "passing tubs. When an approaching tub comes in contact with the tapered end of the "beam, the deepened sides gliding over the top of the load, the sheave is raised beyond "the reach of the fork, whilst the sheave in the depressed end of the beam, in advance "bearing down, retains the chain, relieved from the pressure of the sheave under which "the tub is passing, securely within the fork. In a similar manner the departing tub "depresses the end of the beam in the rear, bearing down the chain in the fork whilst "the other sheave is cleared."

THE MINERS' SUNLIGHT ELECTRIC LAMP. P. 113.

MR URQUHART exhibited this lamp, and explained that it was brought out by a syndicate of scientific gentlemen in London. It is a new form of secondary battery, in which the plates producing the current consist entirely of the material required for it without the weight of lead usually present, and herein consists the novelty claimed. It is surprisingly light for an electric lamp, being only four pounds in weight. To eliminate the risk of the light igniting an explosive mixture when a lamp glass is broken it is surrounded with two glasses, and immediately the outer one is broken a spring is released which extinguishes the light. It has been tested in an explosive atmos-

phere and found to go out without causing explosion when both glasses were broken. The lamp has not yet been used, so that costs are unknown, except by estimate, which places the weekly expenditure in upkeep at threepence. The battery can be charged in 3½ to 4 hours. The lighting power is 1¼ to 1½ candles without artificial reflector, and with it 2½ candles, and lasts 10 to 12 hours. J. H.

Proceedings of SOUTH WALES INSTITUTE of ENGINEERS.—Vol. XV.

POETSCH'S FREEZING SYSTEM OF SINKING AT THE HOUSSER PIT, BELGIUM.

By R. DE SOLDRNHOFF. P. 349.

THE Members of the Institute visited the scene of these operations in 1886, and since that time it had been found necessary to double the refrigerating apparatus in order to more rapidly consolidate the quicksand. By advice of Mr Poetsch, the pumps had been kept going, and the surface of the sand free of standing water. Four or five months' operations were practically void of effect in freezing the ground. A report was asked from Mr Poetsch, who, after investigation, advised that pumping should be stopped, because the water raised maintained a temperature of about 12 degrees Centigrade. The pumping would thus seem to have acted as a means of neutralizing the effect of the freezing mixture. The water was accordingly allowed to rise in the shaft, and stood 68 feet above the surface of the quicksand. Freezing was resumed, and within four weeks sinking could be proceeded with within a solid wall of frozen sand 12 to 40 feet in thickness, as was afterwards proved by boring. Sinking was done at from 12″ to 20″ per day. The shaft was 18 feet in diameter, but a square sinking of 8 feet side was first made by stages of 8 feet deep, and securely timbered till the bottom of the quicksand was reached—freezing being continued the while. Widening out and securing the completed shaft with cast-iron tubbing was then proceeded with in similar stages from the bottom upwards. The sinking has been successfully completed to the coal seam.

ELECTRIC PUMPING IN COLLIERIES.

By FRANK BRAIN. P. 363.

AT Trafalgar Colliery, Forrest-of-Dean, a feeder of water had up till May, 1886, been pumped by a water-power pump and a steam pump supplied with steam from two boilers fixed underground. A new pump was then substituted—a double 9-inch plunger with 10-inch stroke—driven by an electric motor making 650 revolutions per minute to 25 revolutions of the pump. The cable is about 2000 yards long. At work experiments gave for the engine 29·49 ind. horse-power to 10·36 H.-P. of water lifted, showing 35 per cent. of useful effect. The loss is apportioned as follows :—

Loss in Engine,	6·49 H.-P.	or	22	per cent.
,, Generator,	4·56	,,	16	,,
,, Line,	3·45	,,	11	,,
,, Motor,	3·00	,,	10	,,
,, Pump,	1·63	,,	6	,,

The first cost of the plant, exclusive of pump and pipes, was £644.

The work done is to pump 114 gallons per minute through 1300 yards of 7-inch pipe rising 300 feet vertically, which cost for one week pumping (22 hours per day), including interest and depreciation at 15 per cent., £7 17s; or

Per H.-P. on water raised,	0·02 pence.
,, 1000 gallons raised,	1·80 ,,

When not required for pumping, the power available is used to assist ventilation by driving a small fan underground. The machine has been found to work very satisfactorily, so far as upkeep is concerned, and without any more serious hitch than a leakage of electricity through failure of the insulation of the conductor in the shaft.

J. H.

TRANSACTIONS OF THE MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

FOREIGN MINING RENTS AND ROYALTIES.

By H. B. NASH. P. 150.

IN 1886 Her Majesty's Representatives in Foreign Countries were asked to furnish certain information on the above subject. In 1887 the reports sent in were presented to Parliament, and this paper gives, in the briefest possible form, the laws relating to Royalties on Minerals, but chiefly coal and Ironstone, which obtain in France, Germany, Austria, Italy, Belgium, Spain, and the United States of America. J. H.

THE CONSTRUCTION OF MAPS IN RELIEF.

By JOHN H. and EDWARD B. HARDEN.

To an individual unaccustomed to the exercise of mental imagery required to understand a topographical map, models or maps in relief must be a great convenience. To have mountain ranges stand out from the surface, and rivers flow in actual valleys, ought to give the school boy, for example, a much clearer idea of the physical features of a country than the sprawling caterpillar-like delineation of the former, or the tortuous black line which represents the latter on the ordinary atlas or school map. To geologists, also, they are invaluable, while lawyers can carry into Court in miniature the mine where an encroachment has been made, or the actual appearance of the ground containing a contested right-of-way, or disputed boundary. The making of these relief maps by various methods and of various materials is described in the paper, which is mainly a compilation giving experience, methods, and opinions of those who have practised the act of producing them. The question of the relative advantages of what is generally termed a natural scale, and of exaggerated verticals is discussed. The author prefers the latter method, provided the exaggeration is not too large, but the point seems to be determined rather by the area delineated, its physical features, and the purpose of the map, than any abstract principles, apart from the undoubted advantage of shewing things in right proportion. J. H.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

PHOTOGRAPHING THE INTERIOR OF A COAL MINE.

By F. P. DEWNEY.

IT seems almost a contradiction in terms to speak of Photography in a Coal Mine, but with the assistance of the electric light a measure of success has been attained. In Kohinoor Colliery, Shenandoah, Pa., the experiment was made in the mammoth-bed, which is there upwards of 40 feet thick. An attempt was first made to obtain a negative with light from magnesium wire, but this was at once proved to be hopeless. The plant necessary for producing light by electricity was fitted up underground, including the engine driven by compressed air already led into the mine for haulage and ventilation. Five lamps, each of 2000 candle-power, were used. Altogether eight negatives were taken, of which five were considered good. The reproduction of three of these as illustrations for the paper does not show this attempt at underground photography to have been an unqualified success. J. H.

EXTRACTS FROM REPORTS OF THE INSPECTORS OF MINES, FOR THE YEAR 1887.

Mr Dickinson, Manchester District.

It will be observed that among the fatal accidents none occurred from explosion of fire-damp. This unusual result with so many gaseous mines is doubtless attributable partly to the increasing use of the Settle water-cartridge, and to watering, improved ventilation, more care generally in blasting, and in some instances to the entire discontinuance of blasting.

No good, however, seems attainable without some drawback. Of the 51 fatal accidents from all causes, 34 were from falls of ground, some of which in the absence of blasting are attributable to persons after having failed to wedge the coal down resuming holing underneath, without, as the rule requires, resetting sprags for support.

Besides the water-cartridge, experiments are being made with the view of finding explosives which of themselves will not inflame gas, and also with the Cunliffe hydraulic coal-getter for forcing down coal.

Mr Wynne, North Staffordshire District.

After more than 30 years constantly bringing forward the question of the use of gunpowder in fiery mines, I have at last the satisfaction of knowing that the district under my charge has nearly altogether abandoned that dangerous practice. And, although my speaking and writing on the subject has been like water dropping on a stone, it has at last made an impression upon those minds that thought of little else than their own convenience in getting coal. Not that I mean to convey an impression that the safety of the men had no place in their thoughts, but the idea had taken such a firm hold on the minds, both of owners and managers, that the coal could not be brought down without the use of gunpowder.

I have many times stated that there was no fear of any failure in the getting of coal by the use of other means than blasting, and the expression I used, that "necessity is the mother of invention," has now been proved to have been literally true, for we have lived to see wedges of all sorts and conditions invented, then lime-cartridges, which in some coals were very effective; and then came Settle's water-cartridge and Heath and Frost's gelatinous cartridge, both, as far as I have seen, safe and efficient; then we are again told that Roburite will supersede everything else, as the inventor states very confidently that it will not only be safe but effective; and now we are also told that an article called Securite is to supersede them all.

On these inventions I have no wish to pass an opinion, except on those which I have seen in use, and my object in pointing out what a number of inventions are offered for the use of miners is to show that whenever a real necessity arises, with a little gentle compulsion, there is scarcely anything in use of a dangerous character for which man's genius cannot eventually find a substitute.

. . . . . .

It is satisfactory to find that neither of these explosions have been due to the use of explosives, which is particularly satisfactory after the awful events which have occurred in this district. The number of explosions has become fewer and fewer in the district year by year, their number being almost at a minimum; this is owing in a measure to the readiness with which owners and managers have discarded the use of dangerous explosives and unsafe lamps, and have attended to the principles of ventilation and other matters pointed out to them.

Mr Moore, Scotland (Eastern District.)

The deaths from explosion are greatly in excess in consequence of the Udston explosion in May last. I have already reported specifically to you on this sad accident. Mr J. A. Dykes, the procurator-fiscal of Hamilton, made a most elaborate investigation. Mr

Dickinson and Mr M'Connechie also held an inquiry. It is unnecessary here to notice the matter further than to confirm my opinion that the disastrous effects of the explosion were due to the ignition of the coal dust in the mine, and not to an accumulation of fire-damp. There had probably been a very small quantity of gas in the place where the explosion began, and a shot fired surreptitiously, without an examination, ignited this gas. This raised and ignited a cloud of coal dust, and the flame, fed by the dust in the workings, traversed the whole seam.

It was suggested that if, at the time of the explosion, the returns were loaded with fire-damp to the extent of 2½ per cent., the atmosphere might ignite under certain conditions.

On 5th September, samples of air were taken from the three main returns, after they had passed all the workmen; and a careful analysis was made of them, with the view of ascertaining how much fire-damp they contained. There is little doubt in my mind that they each contained the same proportion of fire-damp as they did at the time of the explosion.

The following were the proportions of fire-damp :—

Return from	Blantyre	stoops,	·209	per cent.
„	East	do.	·1738	„
„	Dook	do.	·154	„

This view was therefore untenable.

When the colliery re-commenced work, the ventilation and all the arrangements were in every way the same as before the accident, with the exception that no explosives have been used, and I think this gives great additional security.

In October last, a series of water pipes was laid along the main roads, with branches at intervals; and the roads are watered periodically by means of a hose attached to these branches.

This explosion is another argument in favour of the abolition of explosives in all fiery and dusty mines; for although precautions regarding their nature and use are provided by the Act (1887), they are apt to be neglected; or, even if attended to, owing to defects in the apparatus they may be rendered inoperative.

The theory that dust is a factor in explosions has often been noticed by engineers, but until Mr Galloway brought it so prominently forward, it had never received the attention which it deserved. Looking back upon the two great explosions which occurred in Scotland previous to that at Udston,—the Nitshill explosion in 1851, and the Blantyre explosion in 1877,—in the light of this theory, I am strongly inclined to think that the destructive effects of these explosions were mainly due to the combustion of coal dust, and not to fire-damp. With reference to the Nitshill accident, I was in the pit immediately after the explosion, and made a thorough examination of it. The coal was 6 feet thick, with a strong limestone roof, the whole waste was upstanding, and I estimate that in the 70 acres there were 300,000 cubic yards of open space. The coal was dry; the roads and passages were dry and dusty; and, although fire-damp was given off, the workings were well ventilated. This being the state of matters, just when the pit started work one morning an explosion happened, and flame was apparent throughout the whole pit, which could not well have been accounted for by an explosion of fire-damp.

In the Blantyre explosion the workings were all upstanding, and the flame traversed the whole area. The waste here was also dry, and the roads covered with coal dust.

It seems clear to me, then, that greater care and attention will require to be paid to dust as a factor in explosions, more especially in high seams with wide passages, which permit the flame to pass along with less friction.

With regard to the other 8 deaths and 48 non-fatal accidents from explosions, they were all caused by the ignition of small accumulations of fire-damp, the effects of which did not extend beyond the immediate neighbourhood of the point of ignition. They were due either to derangements of the ventilation, or to parties being sent into places which had not been examined, or rashly going into places where they did not expect to

find gas, and where they should not have gone. They might all have been prevented by the use of safety lamps; and it is to be hoped that general rule 8 (*a*) will compel the more frequent use of safety lamps, and thus minimise these accidents.

Safety lamps are now more freely used than they were some years ago. In the neighbourhood of Hamilton, where there is perhaps more fire-damp than in other parts of the district, and where the establishments are on a more extensive scale, there are some collieries worked entirely with safety lamps.

The more approved of lamps are now in use, but the Davy Lamp is still used very generally by firemen when testing for gas; and in my opinion it is the best lamp we yet have for that purpose.

The incandescent lamp is still progressing towards improvement. Lamps of this kind have been exhibited and tried, but they have not, so far, been adopted in any colliery here. If a practical lamp of this kind could be got, suitable for all mines, whether fiery or not, it would greatly minimise the accidents from fire-damp; because there would be no inducements to use, in any circumstances, any other lamp than a safety lamp, and small explosions would cease.

The introduction of ventilating fans in the district has caused a marked improvement in ventilation. I may safely say they have trebled the amount of air sent into the mines, and done away with much of the danger of underground fires, which were frequently caused by the old ventilating furnaces. The first ventilating fan was erected at Rosehall Colliery in 1868; it was a small Schiele fan capable of exhausting 40,000 cubic feet of air per minute. The next was at Greenfield Colliery, near Hamilton, in 1869, a 30-feet Waddle fan. The third was at Carberry Colliery, near Edinburgh. Since then, they have been adopted in nearly every part of the district. In 1873 there were seven fans; in 1878, 84; in 1885, 160; in 1886, 172; in 1887, 186; and probably seven millions of cubic feet of air are sent into the mines every minute, or 345,600 tons every day by these fans, which is eight tons of air for every ton of coal raised.

There are not more than six of these fans provided with duplicate engines; but, in practice, this is not felt to be a disadvantage.

With few exceptions, they are all fitted upon winding shafts, which have moveable covers raised by the cages on reaching the surface. Some of them are forcing fans, which give as good duty as the others, and are in every way as suitable. These latter possess the great advantage that, where the upcast is a disused shaft, and is situated at some distance, the fan can be placed at the working pit, and the fresh air sent down into the workings, any bad air met with in the wastes beyond the working faces being carried away from the miners.

There were a number of fatal accidents by bottomers falling from mid-workings, where tubs of coal are run on while the cage stops in the open shaft. These mid-workings are generally adopted in small collieries where there are two or more seams some fathoms apart, worked by one shaft, and with a small output coming from each. No doubt this arrangement is very handy, but it is not so safe. There are gates put on to shut off the entrances, but somehow the bottomer neglects to shut them, or, from some unaccountable absence of mind, forgets to look if the cage is there, and he runs the tub forward when the cage is not there, with the result that both he and it fall down the shaft.

Various automatic arrangements have been contrived to completely close the shaft while the cage is there, or to shut off the entrances while it is not there; but they are more or less defective, and do not prevent such accidents. I am trying all I can to have a permanent scaffold at each seam where coals are hung on in the shaft, which is by far the best remedy.

The safety of miners in no way depends directly upon the amount of Government inspection, but rests with the owner and workmen—first upon the owner and manager conducting the mines in the most approved fashion, and having a sufficient staff of officials, with proper rules for their guidance; and next upon the officials and all workmen acting up to and seeing that the rules are observed. A mine is unlike almost

any other work. It is physically impossible that the manager can personally see every part of it daily; and, for what he cannot see himself, he has to depend upon his officials carrying out the details of his schemes, and upon every one in it at once giving information of any defect.

Mr WARDELL, Yorkshire and Lincolnshire Districts.

I AGAIN advocate, as I have hitherto done, the extension as far as possible of the St. John's Ambulance Association. The formation of centres is increasing throughout the district, and each year's experience testifies to the benefits resulting from a knowledge of how to render first aid to the injured. Numberless instances have arisen, within my own knowledge, of the probable saving of life, owing to the prompt and able action of members of the Association. One in particular deserves to be recorded. A man was completely buried by a large fall of coal in the Mitchell Main Colliery, near Barnsley. Having been extricated as soon as possible, the underviewer, two deputies, and others present, were of opinion the man was dead, but they determined to try and restore animation, and, after persevering in their efforts for one hour and forty minutes, they at last succeeded in bringing him round. In all human probability, had these members of the Association not been possessed of the requisite knowledge, and acted upon it, the poor man, before medical aid could be procured, would have been beyond recovery.

Mr WILLIS, Newcastle District.

I AM of opinion that the powder gases projected from the shot had raised a cloud of coal dust from the floor into air containing some fire-damp, and that the flame from the shot had ignited the mixture, the expansion accompanying this ignition had raised more coal dust, and the flame had extended in all directions until arrested by a falling off in the quantity of coal dust on the wagonway, and return flame had not passed the wet ground, and in the air-way between the two longwalls faces there was little coal-dust. The amount of fire-damp probably present in the air at the time the shot was fired would have been perfectly harmless in itself, and possibly the coal-dust would not have transmitted flame.

No. 1 accident in list may be taken as a typical case showing that notwithstanding great care and attention on the part of the deputy in the setting of timber, and the supposed safety of the place on the part of the hewers, yet that a fall of considerable extent may take place without warning. Deceased's father, who worked in the place until relieved by his son and another hewer at 11 A.M., gave evidence at the inquest:—"The place was good when I left it. The stone worked none in the fore shift. There "was plenty of timber in, and also loose timber. I told my son that the stone was a "good deal harder than it had been, and that there was a plank at the face. "I considered the place quite safe." Deceased's partner testified:—"The deputy was "last in about an hour before the accident. He examined the place and set timber on "both sides. The stone gave no warning. The stone had not worked any during my "shift. There was loose timber, if required, and we thought there was no danger." The deputy's evidence was that he "commenced work at 7 A.M., and was in the place "three times, the last time about an hour before the accident, when he set six or "seven props, jowled the roof, and, as he thought, left the place safe. The stone "which fell was about 2ft. 10in. thick, and had fallen over an area of about 9ft. square. "The stone 'canted' the timber, and he saw about 12 props which had thus been "displaced."

No. 42 in list. Deceased and his mate were engaged in driving a level stone drift. He and his mate drilled a hole for a sumping shot at the face, and charged it with 1½ lbs.

of powder. They retired to about 70 yards from the face, deceased being furthest outbye. When the shot exploded a piece of stone weighing about one cwt. was blown outbye, and is not known to have touched anything until it reached a ventilating door 50 yards from the shot, half of which it carried away. It passed on and appears to have struck the side at 56¾ yards from face; it then passed one of the men without harming him, and struck deceased about 70 yards from face, and passed three yards further. The men could have taken refuge at a point 40 yards from the face, and would have been safe, but it appears that the concussion of the shots occasionally put out their lights when in this place. The accident was of a very extraordinary and unexpected nature.

Dr. C. LE NEVE FOSTER, North Wales, &c., Metalliferous Mines.

GOLD MINING IN MERIONETHSHIRE.—The question whether it will pay to work gold mines in Wales has once more come to the front, and now that stamping has been going on at Mount Morgan mine for nearly three months we have data upon which to base a reply. I am informed by Messrs Pritchard-Morgan & Co., the owners of the mine, that since the middle of January this year they have stamped 555 tons of quartz, and have obtained 1,182 troy ounces of gold. Such brilliant results as these must not be expected everywhere; but when we reflect that profits are being made in Australia and the United States upon quartz containing only a few pennyweights per ton, there seems to be a very fair chance of success in Wales, especially in situations where mining can be conducted by adit levels without any expensive pumping machinery, and where the milling can be done by water power. No doubt there have been disastrous failures in the past, and it is certain that there will be similar mishaps in the future, unless each new scheme is very carefully examined by competent experts, and unless the public refuse to invest in any company which is weighted with too heavy a capital.

Mr BELL, Durham District.

I AM pleased to say that there have been no accidents from explosions of gas in this district during the year. The use of explosives in mines containing gas, especially where they are dry and dusty, has been much more carefully attended to since the last fatal explosion at Elemore Colliery, and I find there is a growing disposition on the part of owners of mines to discontinue the use of gunpowder and to substitute such explosives as are yet best known to produce no flame.

Falls of roof and side are unusually numerous this year. Seventy per cent. of these accidents take place from breakers in the roof while turning away out of or holing into old or disused places. Many years of experience have taught me the lesson that by the side of every cutting, whether board or wall, breakers are formed after the places have stood for a time, and if the greatest care be not exercised by setting up props and cross planks into the face and following them up at close intervals, a fall of stone is the inevitable result. The same rule should be observed while holing through or into old opens. I have frequently called attention to this source of accident both in these reports and at numerous inquests. As the warnings seem not to be heeded, accidents continue to prevail, and coroners' juries are too prone to return verdicts of accidental death.

There have been no less than 30 deaths from accidents on engine and incline planes, by machinery underground, and by trams and tubs. This is the largest number recorded from this cause for over twenty years past, and may be considered a most unsatisfactory result. The deaths caused by trams and tubs are chiefly of boys of from 13 to 18 years of age employed as putters, who get crushed between the tubs or between tubs and props or the side of the way. Those killed on incline and engine planes

are mostly boys of from 14 to 18 years of age employed as attendants. The others are persons of riper years, who work on the roads or planes, or are often persons caught by the sets while passing to and from their work. It is to be hoped that the new general rule, No. 14, will be the means of preventing many of these accidents. Some stringent rules are required to prevent people walking on self-acting incline planes while the sets are in motion, as well as to keep the boys or other attendants within their refuges until the sets are at rest, so as to prevent accidents in case of broken ropes, chains, or couplings. I also think that workmen or boys ought not to be allowed to ride on sets or trains of tubs unless they are specially set aside for that purpose, and are under the charge of a competent person as guard.

The St. John's Ambulance Association is now, I am glad to say, fairly established in this county. At all the important collieries and mining centres, classes have been established. The doctors in the district have very handsomely come forward, and are giving gratuitously lessons in rendering first aid in cases of accident until medical advice can be procured. Great praise is due to Surgeon-Major Hutton, A.M.D., and his two secretaries, Messrs Waynman Dixon, of Middlesbro', and C. E. Edgar, of Bishop Auckland, for their great trouble, and for the time which they spent in successfully organising classes throughout the county during the last summer. Many of the workmen have had practical experience in the usefulness of those lessons, and are becoming daily more anxious to attend the classes.

Mr HALL, Liverpool District.

During the last six years, three heavy explosions have occurred in this district, all in the same seam of coal (the Wigan 6 feet), but at collieries a considerable distance from each other, under precisely similar circumstances to those at Brynn, and in each case but for the precaution of blasting only in the absence of the workpeople, there would have been a very serious loss of life. It has, in my opinion, been due to the above precaution being generally taken in dangerous seams that the district has kept clear of any great disaster during this period.

Personally, I regret very much that the new Act of Parliament does not contain an enactment making it compulsory to blast only in the absence of the body of workmen from the mine. A clause of this kind would have been generally accepted, but for the action of the South Wales Colliery owners and workmen—a district where, from the nature of the coal-beds, the inconveniences would have been least felt, and where from past experience it is indisputably most needed. I know it has been urged against this proposal that it is unfair to subject a small number of men at night to the danger of blasting, but it is certainly a less evil than subjecting all the men in the mine to the same danger in the daytime.

However, we must hope that the strict enforcement of the precautions of watering dusty mines and the use of explosives emitting the least possible amount of flame, as required by the new Act of Parliament, will be found to be effective. The managers do not appear yet to have settled down to any regular system of effecting watering of the workings, but in some instances tanks and water-cans have been introduced, and I think they are proving more useful than most managers were disposed to grant. The flameless cartridge has been adopted by several firms—that is the "Settle water cartridge," which at present appears to take the lead; it does its work very well on stone, and promises to be a successful substitute for gunpowder. There are several other explosives in the market which the patentees represent as being flameless; the most important of these is "Roburite," which it is hoped may be used without the water envelope. Large works for the manufacture of the explosive are being constructed in the neighbourhood of Wigan.

In one or two cases, iron pipes, an inch in diameter, have been carried along main

dusty roads with taps at every twenty yards or so, through which water under a head of 150 yards of pressure is allowed to flow, and, passing through ordinary gas burners, is emitted as fine spray. This system is an excellent one for main roads, but it would be very difficult and costly to apply it to the working places. As yet, the watering of the dust in mines is far from being as effectively done as was contemplated by the Royal Commissioners or as the new Act of Parliament seems to require, but some progress has been made.

A great change has taken place during the last two or three years with respect to the kinds of safety-lamps used in mines. The old-fashioned "Davy" has been almost universally discarded, and lamps of a new type introduced, these latter being largely constructed of glass, so as to obtain a better light, such as the "Mueseler" and "Marsaut" lamps, and are so shielded as to withstand high currents, but many practical men, more especially managers who have raised themselves from the ranks, hold the opinion very strongly that the increased use of glass without a protecting gauze in the new lamps will eventually prove a greater danger through *accidental breakages* than the danger that existed where unprotected "Davys" were in use, *of the flame being passed through the gauze in high currents.* This change, which is now imperative under the Act of 1887, has not been adopted with any great amount of confidence as to any beneficial result, because the best lamps in the market even now are far from ensuring any high degree of security.

I have frequently drawn attention to the system of timbering adopted in this district, which by custom is entrusted to the miners themselves—a duty which they willingly undertake, but which is often performed in an unskilful and careless manner. I find it very difficult to get the officials to recognise any great amount of responsibility for the security of the timbering where the workmen in this way undertake as it were their own safety. However, the special rules formed under the new Act of Parliament, by compelling a supply of suitable timber to be *constantly* kept at the "shunt," will, I think, make the system work much better.

Mr SCOTT, South Staffordshire District.

In this report I am able to record the least number of deaths under this head which has taken place in South Staffordshire, since my statistics have been undertaken, in any one year.

Only 15 deaths from this cause leads to a considerable emphasis being placed upon the word "only." I quote myself, when I again state, as I have done in former reports, that the death-rate in 1855, more than thirty years ago, in the infancy of Government inspection, was by falls 99, and the average of loss by falls, as already given, for the period of the existence of the 1872 Mines Act was 27·3 per annum. Small as is this total when thus compared with years gone by, it might have been reduced by seven, if the carelessness of men through long familiarity to danger could be done away with. These seven lives were lost through men breaking the most elementary mining rules—by lying under the holing without setting sprags to support the working face; by passing the line of timber into the abandoned portion beyond, after warning; by entering wastes; by stepping under top coals where they had cut and loosened them. The other deaths were caused by sudden falls of huge masses of coal in Thick Coal openings, where everything had appeared safe only a moment before, and where it was intended to get the roof coal down by blasting, or where the timber set up to support the roof had itself also been knocked out by the falling roof.

Mr RONALDSON, Scotland (Western District.)

It will be seen from this table that last year is the best by far as regards immunity from fatal accidents, there having been one death for every 868 persons employed. The

nearest approach to this was in the year 1876, when one person out of every 660 persons employed was killed. As regards immunity from fatal accidents, this district last year shows a more favourable result than any other in the kingdom, the average of all the districts being one life lost out of every 529 persons employed. It is gratifying to be able to record such a favourable state of matters, but when one considers what a slight difference there really is between what causes a fatal and a non-fatal accident, the result depending upon the manner in which a stone may fall or the position of the person's body, and when one thinks of the many hairbreadth escapes the miner has from sudden death, it is not surprising to find that the annual number of accidents fluctuates considerably. Already, so far as this present year has gone, the number of deaths is considerably above the average.

A rather peculiar explosion—No. 110 in Schedule 2 at the end of report—by which four persons were injured, illustrates one source of danger arising from the use of mixed lights. A section of stoops was being worked with safety lamps, and open lights were in use in other parts of the mine. The overman, accompanied by the fireman, went to visit the miners working at the stoops, and on reaching the station beyond which naked lights were not allowed, he put up his hand to extinguish his open lamp which was upon his head. With a safety lamp in his hand, he then proceeded behind the fireman. Upon reaching one of the working places, he began with his safety lamp to test along the roof for fire-damp, when his naked lamp, which he imagined had been extinguished, ignited some gas, and the fireman and three miners were injured by the explosion. The overman stated that his naked light had almost gone out for want of oil, and the light given from it was so feeble that it was only a moment before the explosion ere the fireman noticed that it had not been extinguished.

The non-fatal falls numbered 60 as compared with 74 the previous year, and formed 43 per cent. of the total number of non-fatal accidents reported. Of these, exactly one-half were by falls of roof, and the other half were by falls of side. Judging from a careful investigation of all the fatal accidents, apparently 8 out of the 17 deaths by falls would not have happened had ordinary care in supporting the roof been exercised, and a large proportion of similar non-fatal accidents were due to the same cause. This proves not only the need there is on the part of the miners, who by arrangement with their employers prop and sprag their own working places, to use every precaution, but also the necessity on the part of those who carry out the details of management to see that the miners attend to their own safety. The condition of the roof and working face is constantly varying, and therefore, as the responsibility of keeping secure the roof and sides lies with the mine owner, frequent visits to each working place by the officials of the mine are required. When it is considered that, since 1872, 42 per cent. of the total number of deaths by accident in the United Kingdom have resulted from falls, one would have expected some additional regulations to be embodied in the General Rules of the Mines Act of 1887 to deal with such an important subject, but while the most elaborate and stringent rules are laid down with the object of dealing with fire-damp and dust explosions, by which 21 per cent. of the lives have been lost during the same period, little has been added to the Act of 1872 except the insertion of General Rule 22, which provides for timber being laid down in places convenient to the workmen, and specifies that the distance between sprags or holing props, where they are required, shall not exceed six feet or such less distance as may be ordered by the owner, agent, or manager. While General Rule 21, which is the same as General Rule 16 under the old Act, enjoins that the roof and sides of every travelling road and working place shall be made secure, experience has taught that this leaves too much to the discretion of the miners and those entrusted with the details of management. A Special Rule defining definitely the distance which must not be exceeded between sprags and props at the working face would serve the same purpose as a General Rule to that effect, but apparently a decision by arbitration must be got before such an addition to the new Special Rules at present being prepared will be accepted by the mine owners.

Mr ROBSON, South Wales District.

THE most important part of the district is situated in Glamorganshire, all of which county, with the exception of a narrow strip bordering on Monmouthshire, and accessible from the Newport and Rhymney Railway, is embraced in it. In the eastern and central portions of the county there were during the past year 108 collieries working one or more of the steam coals, and 70 working house, coking, and manufacturing coals.

The steam coals are raised from various depths up to 720 yards, the average depth being 260 yards; most of the coal, however, is worked at a depth of from 400 to 500 yards. The seams vary from about three feet to six feet in thickness in general, one seam being nine feet thick. They are exceedingly dry as a rule, and this, with the comparative flatness of the coal-field, enables coal to be worked almost as easily from the dip as from the rise. Many of these collieries are extensively developed, and engine power is much employed in haulage.

With the exception of a few collieries—some of which, however, are deep and important—they are lighted exclusively by safety lamps. The system of working is almost invariably that of longwall.

In the western portion of the county of Glamorgan the seams are of various kinds, and anthracitic, semi-anthracitic, coking, house, and manufacturing coals are raised.

There were 87 collieries at work during the year, in 31 of which the coal was worked at a depth of 20 to 410 yards, the average depth being 126 yards. The remaining 56 are either levels, or inclines dipping from the surface.

The seams vary from 16 inches to 12 feet in thickness. Both the longwall and pillar and stall systems are adopted, according as the circumstances may vary, but most of the coal is worked by the latter method, which in some old collieries appears to have been adopted at first and steadily adhered to ever since.

Although none of these collieries is so extensive as the largest of those in the eastern portion of the county, many of them are fairly large collieries, and this part of the county will probably be more developed in the future.

Inflammable gas is produced to some extent in nearly all, and especially in the deeper of these collieries. In a few instances safety lamps are used entirely, and in most cases occasionally.

In Breconshire, into which the northern outcrop of the coal measures extends for a few miles, there were only six collieries at work during the year. The greatest depth from which the coal was raised is about 110 yards. The coal is anthracite, from three to four feet thick, and worked by the pillar and stall method. Fire-damp is produced in these seams.

In the county of Carmarthen, there are 38 collieries working coal; these are for the most part small collieries, working rather thin seams at depths averaging 116 yards; the deepest shaft at work is 360 yards. The pillar and stall method is almost invariably adopted in this county. The coals are various—anthracitic, manufacturing, and house coals. More water is met with here than generally in the district. The seams give off little fire-damp, and in only a few cases are safety lamps in use, excepting for examination of the workings.

There were 10 collieries working coal in Pembrokeshire during the year; most of these are very small, from 10 to 20 yards in depth; the greatest depth at present worked is 210 yards. The seams are from 16 to 22 inches thick, and all pure anthracite. Occasionally fire-damp is met with in small quantities.

The greatest factor in explosions is fire-damp, at least in their initial stage, and the prevention of accumulations and the reduction of the percentage of gas in the ventilating currents are matters of the utmost importance, and require unceasing attention on the part of the officials. The steam coal collieries are, with a few exceptions, equipped with modern ventilating machinery, and large volumes of air are in circulation. This, however, is not all that is required, and unless additional air-ways are made and maintained of a proper section throughout, as a colliery becomes more

and more developed, there cannot be such good ventilation at the faces as is necessary to prevent accumulations and an undue proportion of gas in the currents themselves. All this is well understood amongst managers, but still instances are occasionally observed where it is not put into practice so well as it should be. Upon the whole, however, I believe great care is taken to ventilate thoroughly.

As bearing upon the subject, it may be remarked that the necessity for keeping all roadways free from dust is becoming generally acknowledged, and considerable attention is being directed by the owners and their managers to the matter, which, in my opinion, is a very important one.

In nearly all the steam coal collieries, the roadways are watered to keep them moist, and so prevent accumulations of dust. In 18 or 19 collieries this is done by a system of piping, 1½ to 2 inches diameter, commencing at the surface, or some point in the shaft where a supply of water can be obtained at a sufficient head, and laid along the roads. In most examples, the watering is done automatically by jets fixed at intervals of 20 to 40 yards, through which the water issues in the form of very fine spray. The water is thus partly taken up by the current and carried along, with results highly satisfactory, both as regards keeping down the dust and reducing the temperature at the face.

I am hopeful that further improvements will be made, especially as regards the branch roads, which, unless near the main roads, are not in general kept so clear of dust as is desirable. Probably an extension of the piping to various points nearer the faces, with the addition of flexible tubing and nozzles, will be found the most practicable method of watering these roads.

A great many places are also watered by trams, which system, when thoroughly organised, does the work well, so far as regards the floor of the roads. It is not, however, so well adapted as that above referred to, particularly for the sides and timbers, upon which the finest dust collects.

By far the most accidents from falls occur at or near the face, and it is a matter of notoriety that in nearly every case the persons who can speak as to the condition of a place immediately before an accident occurred declare that it appeared safe. In many instances it is not denied that had there been danger apprehended more timber could and would have been set up. These facts show conclusively that many accidents occur through trusting too implicitly in the appearance of a place.

As in this district the work of timbering and securing the working places devolves upon the colliers themselves, it seems to me that supervision by officers, who should be both experienced and thoughtful men, is required of a very superior kind, and that it should have for its object the guiding and directing of the men to secure their places, not only where by a careful examination the need for security is apparent, but also where the experience of the official has taught him that security is required as a purely precautionary measure.

Mr STOKES, Midland District.

I HAVE only heard of, or seen, one report of workmen's inspection of a mine during the year. I find that workmen are slow to avail themselves of the power given them by the Act to inspect the mine in which they work; they appear to think this is the duty of an Inspector of Mines, and frequently send their complaints to the Inspector of the district for his investigation. The New Mines Act, which is now in force, materially extends the workmen's privilege, for the inspection is not now confined to persons working in the mine, but may be made by any two practical working miners not connected with the mine, and the workmen can now call in two of their own class to inspect the mine in which they work.

Much has been said respecting the use of safety lamps and accidents from falls of roof. In my opinion, the modern improved safety lamp with flat wick, and good oil, gives a fair light for examining the roof and sides, and I cannot name a single accident from fall of roof or side which the use of a candle instead of a safety lamp would have prevented. I am pleased to report that the work of teaching colliery officials and others how to

render first aid to the injured is being steadily pushed forward. There are now ambulance men at nearly every important colliery in the district—men not only well qualified to render such aid, but whose knowledge has been practically tested; and they have in many cases rendered valuable service to the injured, and frequently alleviated the pain whilst conveying an injured man from the mine to his home or the hospital.

SEVERAL of the Inspectors have appended to their reports a list of the questions put to candidates at last examination for managers' certificates of competency. J. B.

Transactions of the AMERICAN INSTITUTE of MINING ENGINEERS.

AN IMPROVED SYSTEM OF WATER SUPPLY FOR HYDRAULIC MINING.

By H. D. PEARSALL.

THE machine described was constructed for a mine in Colorado, and is meantime at work of another kind in England. The object of the machine is to utilize the energy of a moving column of water by suddenly stopping it on a principle similar to that of the hydraulic ram. Many modifications of the hydraulic ram are required to make the machine suitable for the large quantities of water to be dealt with, and to avoid the shocks which accompany the working of the former. The column of water which supplies the energy is contained in pipes leading into a chamber through a valve worked by a compressed air motor. This chamber communicates with the atmosphere through a small pipe fitted with a valve attached to a float within the chamber. Immediately above, and connected with the chamber by a valve opening upward, is an air vessel from which the delivery pipe leads. The main valve is opened to allow the flow of water by its own gravity into the chamber, from which the air can freely escape till the water has filled the chamber up to the float, which closes the valve communicating with the atmosphere. What air then remains is compressed, and opens the valve leading into the air vessel, through which air and water pass, and the latter forces its way through the delivery pipe. The valve admitting the water from the source of supply to the chamber is slowly closed as the moving column has expended its energy, and the chamber empties itself by gravity preparatory to a new stroke. The compressed air for the motor, which works the main valve, is obtained from the air chamber—part of the energy got from the machine being, of course, used in working the motor. It is apparent that the moving column of water is brought to rest without shock by the compression of air, and that the quantity of water delivered may be varied by simply regulating the position of the float controlling the escape of air from the chamber. In this way the machine may be used as an air compressor. It is stated that, with a head of supply of 17 feet and a head of delivery of 150 feet, the efficiency was found to be 70 per cent., and that, as an air compressor, its efficiency in actual experiment was as high as 90 per cent. It is proposed to construct and erect a machine in Colorado to deliver 10,000 gallons per minute. J. H.

TRANSACTIONS OF MINING ASSOCIATION AND INSTITUTE OF CORNWALL.
VOL. II., PART I.

THE VENTILATION OF CORNISH MINES.

By MR J. HUSBAND.

The author describes the following as a mode of ventilation recommended by his father. A connection with the pumping engine actuates a piston working in a simple double acting air cylinder, the air from either end being delivered into a light air box, which is connected by means of air pipes to the desired points of operation underground. "Such a box, say four feet square, working at 3 feet stroke, would supply when work-"ing, say, six double acting strokes a minute, more than 800,000 cubic feet per 24 hours.

"This quantity, though small as compared with the actual requirements of perfect ven-
"tilation, would greatly improve the existing conditions under which our agents and
"miners have to carry out their important and arduous duties." Surely the circumstances are exceptional in which this would be regarded as adequate ventilation.

FOREIGN MINING LAWS.

By ARTHUR STRAUSS.

This paper briefly refers to the outstanding features of the mining laws in Germany, France, Belgium, Austria, Spain, Sweden and Norway, Italy, and the United States. It also describes the law and custom in Germany in connection with the establishment of mining companies and regulations as to the employment of miners, as well as some details about the operations of the miners' friendly societies.

SOME MINING NOTES IN 1887.

By C. LE NEVE FOSTER.

These are extracts from the note book of the Author, who in the capacity of Inspector of Mines had opportunities of seeing what he describes.

Iron Supports for the Halkyn Drainage Tunnel.

Columns of cast-iron, 6ft. 6ins. long, 5ins. dia. outside, and 4ins. dia. inside, with a flange 8ins. dia. at the top, and 9ins. dia. at the bottom, are set three feet apart on both sides of the mine where the strata need support. The width of the mine between the columns is 4 feet. Into the top of each column is set a chair. The chair receives a flat-bottomed rail, 50lbs. to the yard, set with the flat upward. This serves as a crown. On the crowns planks are laid, and the space between the planks and the roof is packed with stones. The sides are built with stones, with an occasional plank to make the wall firm. When the side pressure is not great, this method is found suitable, and costs £2 4s per lineal yard of tunnel, as against £4 for lining of brick and cement.

Steel Beams at Nunnery Colliery, Sheffield.

Steel beams of I section, 4ins. wide, 5ins. deep, with the web ⅜in. thick, are used sometimes as legs and crowns, and sometimes as crowns only. They are said to be as strong as 12 inch Norway balks. The sets are usually placed 3 feet apart, and old timber laid on the top for lofting. Covered with unboiled gas tar they shew no signs of deterioration in two years, which is the average life of English larch or Norway timber. The first cost of the beams is 8s per 10ft. length. The same length of 12-inch Norway wood costs 7s 1d. The advantages of steel over timber are (1) greater durability and less cost in repairs, (2) possibility of being taken out and used again, (3) lightness and handiness, (4) increased space for ventilation, (5) less deterioration of the air of the mine by decaying timber. [It may be mentioned that this system of supporting underground roads is in use at Fence Colliery, Lesmahagow.]

Salt Working near Middlesbrough.

The modes of boring to the salt beds and pumping the brine are fully described.

Underground Stone Quarries near Bath.

Beds of freestone from 8 to 24 feet thick are worked by stoop and room (similarly to the Giffnock Quarries near Glasgow), with main headings, 15 or 16 feet wide, side places, 20 to 24 feet wide, and pillars, 10 feet square and upwards. The bed is holed in 5 feet at the top across the whole width of the room, and then, by means of saws, a block slightly wedge-shaped, is cut out of the middle, and wedged up from the bottom. After this block has been got out, the rest is cut out with the saw and wedges in a similar manner.

Labour-Saving Appliances at Frongoch Mine.

These are: self-discharging skip; self-discharging waggon; jigger; and separator or classifier.

The notes are well illustrated by wood-cuts. J. B.

Minutes of Proceedings of the INSTITUTION of CIVIL ENGINEERS.—Vol. XCII.

MINING APPLIANCES IN WESTPHALIA.

By Messrs MALHET, DE GOURNAY, and SUISSE. P. 367.

THIS paper is translated by Mr William Silver Hall, and in it are noted some things which will interest mining men of other nationalities.

At the Zollverein Colliery, tubes of corrugated galvanized iron, 7½ inches diameter, and costing 2s 9d per lineal yard, are used for ventilating the headings. The steel winding ropes are attached to the cages, not by the ordinary "hose" or "capping," but by being doubled round a sort of sheave, 16 inches in diameter, carried by the cage, the rope end being clamped to the standing part of the rope by bolts and screws. The cages are closed in on three sides by plate iron, and, when men are riding, doors are hung on the remaining side. The winding drums, which are cylindrical, are all loose on the shafts to allow for the adjustment of the ropes, and are fastened by four bolts to a fixed disc, in which there are 64 holes available, the distance from hole to hole corresponding to 16 inches on the rope—the finer adjustment being effected by means of a screw coupling between the rope-end and the cage. The enginemen cannot see the pit mouth and regulate the winding entirely by the indicators, and all the engines are fitted with an arrangement for applying a steam brake at the completion of each run, so as to prevent over-windin .

At the Carlsglück Colliery, near Dortmund, the winding drums are coned to an angle of 25°, their least diameter being 18ft., and their greatest 21ft. 4ins. The winding ropes are of steel, 1 7-16ths inches in diameter, composed of wires 0·0748in. thick, having a breaking strain of 992lbs. when new, and they stand 14 to 17 flexions through an angle of 180° when held in the jaws of a vice rounded to 3-16ths inch. About 13ft. of rope is cut off every month, and the wires tested, and it is found that, while the tensile strength of a wire after 17 months' use is increased to 1008lbs., it will give way after 6 or 7 flexions. When the wires are found to break with 5 flexions, the rope is taken off.

At the Bonifacius Colliery, three miles east of Essen, "in driving parallel roads, holes "for ventilation, 1ft. in diameter, are pierced through the separating wall by means of "a hand-boring machine consisting of a toothed crown, mounted on a stem, passing "through a screwed sleeve for feeding up the tool to its work. The stem is composed "of short lengths, which are screwed on to each other as the work progresses, and, as "the resistance is considerable, the motive power is given by a worm wheel and worm "driven by two crank handles. Four men can bore 20 yards in 8 hours."

At the Rhein-Elbe Colliery, the safety apparatus for the prevention of over-winding rolls a weight on to the brake lever.

At the Prosper Colliery, Wolf lamps are in use, the gauze having 1296 apertures per square inch, as compared with 900 in the Mueseler. They are locked by an arrangement that can only be opened by a magnet, and there is a ribbon dotted with detonating fulminate for re-lighting. The cages are 33ft. high, four-decked, and carry only one tub on each platform. Running on is done simultaneously at four levels served by a drop pit. The pulleys are carried on a tower of masonry. The drum of one engine is helicoidal, with spiral grooves, the diameter running from 12ft. 7in. to 28ft., while that of another is cylindrical, 32ft. 10in. diameter, and with the latter a balance rope is used, and it gives the best results both as regards the life of the ropes and facility and regularity of working. The steam pipe of the pumping engine is 25in. in diameter, and is carried on rollers. At first, steam was turned gradually on, but that practice is now abandoned, as it was found to cause ruptures by unequal heating of the upper and lower parts of the pipe.

One pit at the Hugo Colliery is 314 fathoms in depth. The total weight on the rope is 142cwt. and they are made of steel tapering from 1½in. to 1 5-16ths inches diameter, and are wound on helicoidal drums 11½ft. to 31ft. diameter. Shaft and drums together weigh 50 tons. A rope draws 150,000 tons of coal, besides other things, and lasts 18 months.

At the Shamrock Pit, the cage carries 8 tubs on 4 decks, and the total load (including the weight of the rope) is 256cwts. The ropes are of steel, 1 13-16ths inches in diameter but only last from 8 to 9 months. The coal-washing apparatus is capable of treating 1000 tons per day of 12 hours.

The Providence Pit of the Herne-Bochum Colliery is to be 437 fathoms deep. The head gear is 103ft. high, built of channel iron, and weighs 50 tons. The pulleys are 19ft. 8in. diameter, and the drums 26ft. 3in., cylindrical, and made in halves, so as to allow of the adjustment of the ropes, which overlap each other on the drum as the one is wound off and the other wound on.

The Hanover Colliery, belonging to Mr Krupp, is the place where Mr Koepe first applied the system of winding gear with which his name is associated. The fly-wheel, 24ft. 9in. diameter, of an old engine is converted into a single grooved pulley by blocks of beech-wood bolted to the rim. The pulleys are 19ft. 8in. diameter, and both in the same vertical plane. There is a balance rope under the cages, and the total load is 133cwts., which is carried by a rope of soft iron wire, 1 9-16ths inches diameter. The length of the rope is accurately adjusted by screw couplings at the cages, frequently when the rope is new, but after a few days' work it requires no further attention.

At No. 2 Pit of this Colliery, Mr Koepe proposes to put the driving wheel directly over the pit, the engine cylinders being diagonally fixed on a triangular iron frame on the top of the masonry tower carrying the head gear. It is stated that, although Koepe's system has been adopted in Upper Silesia, at Stassfurth, and in England, it has been abandoned at Westhausen and Oberhausen, and is making no progress in its native district in spite of the increased life got out of the ropes.

At the Rhein-Preussen Colliery, the headings are driven at the rate of 112 yards per month by means of Brandt's hydraulic boring machines, three shifts of 5 men each being employed.

The Carlswerk wire rope works, at Mulheim, and the Grimsberg works, at Dortmund, supply the whole of the Westphalian collieries. The taper ropes are here made by gradually introducing finer wires, which are welded to the ends of the coarser ones. Ropes can be made of cast steel wire, having a breaking strain of 114 to 127 tons per square inch, but these the makers do not recommend, preferring to supply them from wire bearing a strain of 78 tons on the inch. Galvanized ropes are used in upcast pits, and in the Hartz mines, where the water is acid. Their adoption has resulted in a saving in the proportion of 8 to 5. The Dortmund Chief Court of Mines permit a load on the rope of ⅛th of the ultimate breaking strain, where men are wound, but where balance ropes are used the load must be reduced to 1-12th, and this latter proportion is stated to be the result of some alarm which was caused by a case of breakage which was, without much reason, attributed to the extra weight of the balance rope under the cage.

The following general rules are (among others) recommended both by authorities and makers:—

(2.) Diameter of drums and pulleys to be at least 100 times that of the rope.

(4.) The bottoms of grooves to be semi-circular, of the same diameter as the rope, so as to avoid all tendency to flattening.

(7.) All sudden changes of speed in winding should be avoided.

(8.) Some yards should be cut off the rope-ends at least every three months.

(10.) Whenever possible, spring couplings should be introduced between the rope and the cage.

AN UNDERGROUND PUMPING ENGINE AT MECHALKOWITZ IN MORAVIA.

By R. SAUER. Foreign Abstracts, p. 500.

THIS engine is designed capable of doing the ordinary work of pumping 110 gallons per minute from a depth of 135 fathoms, while, by altering the method and speed of working,

and increasing the size of the pump plungers, it is in a position to cope with 900 gallons per minute. It is of the compound receiver class, having two cylinders, 20in. and 27½in. diameter, by 27½in. stroke, coupled to the same shaft, Each piston rod, by means of side rods, drives two single acting plunger pumps placed back to back. For ordinary working, with 45lbs. boiler pressure, the plungers used are 4in. diameter, but in forced working, with full-pressure steam in both cylinders, 6in. plungers are substituted. The rising main is designed for a maximum discharge of 1,100 gallons per minute, and is only 6.3in. diameter, and has proved sufficient. The boilers are on the surface, and provision has been made for carrying steam to the engines when working at full power. If one pipe were used it would require to be large enough to carry the maximum supply; and when the engines were doing only the normal work there would be excessive condensation due to the large surface area of the pipe. To avoid this there are two lines of pipes, one of 3½in. dia., sufficient for ordinary work, and another of 7·9in. bore, which is used when the pumps are going full speed.

The engines were made by the Prague Engine Company, and have been worked compound up to 106 revolutions per minute; and with full steam in both cylinders, and the larger plungers attached, up to 100 revolutions.

The loss by condensation in the pipes (which are covered with non-conducting material) has been found to be 0·17lb. per square foot of pipe surface, per hour, for the larger, and 0·19lb. for the smaller pipes, with the engines standing; and when they were at work the corresponding figures were 0·19lbs. per square foot, per hour, for the larger pipes, and 0·25lbs. for the smaller.

The measurement of the pump discharge was 95·5 per cent. of the volume described by the plungers.

Ten-hour experiments made in compound working, at speeds at from 30 to 85 revolutions, gave a steam consumption (exclusive of condensation in pipes) of 23·7lbs. to 32·4lbs. per hour per effective horse-power in the pumps; and when working with full steam and the large plungers, at from 30 to 65 revolutions per minute, the steam used varied from 31·1lbs. to 33lbs. per hour per effective horse-power in the pumps. The calculated efficiency of the engines working with full steam is 86·75 per cent., and 79·5 per cent. when working compound.

The cost of the entire plant, including excavations, masonry, and erection was £4,654.

COST OF COLLIERY SURVEYS IN WESTPHALIA.

By H. Werneke. Foreign Abstracts, p. 500.

From statistics obtained from the Royal Mining Department, it appears that the expenditure on the preparation of mine plans and on other mine surveying operations amounted to 8¾d for every 100 tons of coal raised.

RACK RAILWAY ON MOUNT PILATUS, SWITZERLAND.

By A. Frank. Foreign Abstracts, p. 461.

Steep gradients have often to be overcome in and about mines, and although in this country we have no examples of the use of the rack rail, it appears to be a practicable appliance after the limit to adhesion has been reached.

The total length of this line is only 2 miles 61 chains, but in this length it rises 5,363 feet, giving a mean inclination of 1 in 2·8, and the steepest gradient is 1 in 2. The gauge is 2ft. 7½in., and the sleepers are of iron and bolted to two parallel longitudinal walls, and the central rack rail is of steel, flat on the top, with teeth on each side for gearing into the horizontal pinion driving wheels of the locomotive. On a steep incline like this the efficiency of the brakes is of the highest importance; the pinion wheels are controlled by hand-brakes, and there is an atmospheric brake, and also an automatic brake which comes into action whenever the downward speed exceeds three miles per hour. On account of violent storms which occur on the mountain, side clamps fixed to the engine frame, and underhanging the rail heads are used to prevent the wheels leaving the rails.

THE MÖLLENTHALL RAILWAY.

Foreign Abstracts, p. 460.

On this railway the comparatively level portion is worked in the ordinary manner by adhesion, and the steep inclines with the aid of a rack rail. The locomotives have four cylinders—two for actuating the ordinary adhesion wheels and two for driving the toothed wheels on the rack. The steepest gradient worked by adhesion is 1 in 40, and by rack rail the inclinations vary from 1 in 26 to 1 in 18. The line is single, 4ft. 8½in. gauge, and the average cost of the tunnelling was £44 3s 10d per lineal yard.

PANAMA CANAL WORKS.

By Max de Nansouty. Foreign Abstracts, p. 446.

The level canal from sea to sea, as originally designed, was to be 46 miles in length, 72 feet wide at the bottom, and 131½ feet at the water level, the deepest cutting being 333½ feet to the bottom of the canal, and the total excavation was estimated to amount to 176½ million cubic yards. Of this there is still to take out over 137 million yards, an amount of work so great that the Canal Company now propose to complete the canal provisionally with locks, which would reduce the quantity of excavation necessary to be done before the opening to 52 million cubic yards, an amount which will be accomplished in 1890, by excavating at the present rate of a little over one and a half million cubic yards per month. J. G.

Transactions of the MANCHESTER GEOLOGICAL SOCIETY. Vol. XIX., p. 505.

MINING RENTS AND MINERAL ROYALTIES.

There are several papers on this subject in continuation of, and in reply to, one recently read before this Society by Mr Percy. Properly speaking the subject is one of political economy, as the papers discuss the ownership of mines at home and abroad, and royalties at home and abroad, as well as fixed rents and sliding scales. The principal essay is by Mr Oswald Walmesley, a solicitor, who has no leaning to confiscation of mines or interference with contract, but thinks something might be done by the Legislature in the way of removing the disability of trustees to revise leases and grant renewals; and also to obviate the necessity for the reservation of heavy fixed rents by authorising specific enforcement of covenants for the proper and continuous working of mines. He also suggests that legislative provision should be made for the regulation of wayleaves through intervening properties if the proprietors thereof will not consent.

ON THE ARTIFICIAL REPRODUCTION OF MINERALS AND ROCKS.

By Mr Vaughan Cornish. P. 477.

This paper gives a good idea of the methods now employed in the investigations of chemical geology. Chalk was at one time supposed to be converted into marble by the action of heat, but if chalk is heated artificially the carbonic acid goes off, and only quicklime remains. Hall, however, towards the end of last century, proved that, when the operation is conducted under sufficient pressure, carbonic acid does not come off, and marble is produced. Immense pressure, great heat, and operations spread over long intervals of time, have been, in fact, the great modifying forces of nature, which it is difficult for chemists to bring into play in laboratory experiments. Nevertheless, several Frenchmen have pursued the subject successfully, and have been able to conduct their operations under pressures of 10,000 atmospheres, and, by the aid of electricity, to obtain temperatures up to the melting point of platinum. By the method of igneous fusion described in the paper, MM. Fonqué and Lévy have been able to reproduce many eruptive rocks. J. G.

JOURNAL OF THE BRITISH SOCIETY OF MINING STUDENTS.
VOL. X.

THE HAULAGE OF COALS AT EMMA PIT, TOWNELEY COLLIERIES.

By F. R. SIMPSON. Pp. 172-5.

AT these collieries there are five self-acting incline planes, varying in length from 270 to 837 yards, and in inclination from 1 in 11 to 1 in 14; two engine planes worked on the tail-rope system, each about 900 yards long and nearly level; and also five horse roads, running from 352 to 1300 yards in length—all the coal being drawn to the horses by putters for distances of 120 to 200 yards from the faces. All the inclines are worked with drums except one, which has a clip pulley, but the charcoal iron rope on it has a duration of only one year, while the steel ropes on the drums last from four to six years. The output is 2,520 tons per week. The cost is tabulated in the paper as follows:—

	Cost per Ton.	Cost per Ton. per Mile.	Aver. Distance. Yards.	Tons Hauled per Week.
Putting, ...	3·4d.	2s 11·6d.	168	2,520.
Horse Road,.. ..	3·0d.	7·3d.	721	2,520.
Inclines, ...	1·6d.	5·3d.	509	1,428.
Engine Plane, ..	1·6d.	3·1d.	909	1,722.
Total Cost, ...	8·5d.	6 5d.	2,307	2,520.

The cost of 5·3d per ton per mile on the inclines is very high, and the writer of the paper appears to have fallen into the error of assuming that the mean length of all the roads was, in each case, the average distance over which the coal was conveyed, but that is not so. The average distance a ton is conveyed on the inclines is 1117 yards, and the cost per ton per mile should be 2·5d. J. G.

TRANSACTIONS OF THE CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS. VOL. XVI.

SAFETY LAMP TESTS. P. 165.

IN June, 1887, Professor Arnold Lupton made a series of tests with apparatus erected at the Neepsend Gas Works, Sheffield, in which an explosive mixture at a pressure of 3″ W.G. could be maintained on the side of the lamps. Mr Lupton did not observe the velocity, but deduced it from the pressure. It was, however, felt necessary to determine it directly, and experiments were made with the apparatus for this purpose. The test tube was 12″×4¾″, and when a lamp was placed in it there was a clearance of 7 square inches. With the lamp in the tube, and a W.G. of 4″.5 on its windward side, the pressure on the lee side was 0″.15 W.G., and the velocity at the exit end of the tube, 54 square inches in area, taken by different anomemeters, ranged from 680 to 1120 feet per minute, the mean being 870 feet, so that the current passed the lamp at a velocity of 112 feet per second. With no lamp in the tube, and the exit end reduced to 19 square inches, a W.G. of 0″.5 gave velocities at the exit end ranging from 2,764 to 3,760 feet per minute.

It was stated in the discussion, by Mr Garforth, that at the explosion in the West Riding Colliery the velocity at the moment of explosion was 120 feet per second—as it must have required that velocity to move a large pulley which had been displaced. In connection with this subject, velocities in upcasts are mentioned of 43 to 50 feet per second, and the speed of winding stated to be in some cases as high as 47 to 90 feet per second.

STANLEY'S COAL HEADING MACHINE.

By Mr R. STANLEY. Pp. 192-209.

THIS coal-cutter was designed for the purpose of driving narrow mines rapidly, with the view to the winning out of coal for subsequent back working. It is constructed on the principle of the boring mill in use for boring out large steam cylinders, and is driven by compressed air. It cuts an annular groove, 3 inches to 3½ inches wide, and forms a roadway of circular section 5ft. 4in. in diameter. The cutters are carried by radial arms fixed to a central shaft, which is threaded at one end, and gradually advances itself by turning in a fixed nut having three threads to the inch. The machine is set on broad wheels which run on the pavement, and it makes a cut of from 3 feet to 4 feet forward at a time before requiring to be shifted. As the central core of coal breaks down it is shovelled past the machine without stopping. In the ordinary way of working it is said to cut 15 feet in an eight hours' shift, and it cut 21½ yards in a trial of twenty-four hours' duration. It can make its way through roof and pavement metals as well as through coal. Explosives are not required, and when the core hangs it is brought down by wedging. The arched shape of the mines appears to give them strength, and they should be more economically maintained than other sections. The ventilation is carried with the machine, the exhaust being found sufficient, and its use is also stated to result in a greater proportion of round coal. J. G.

Transactions of the NORTH of ENGLAND INSTITUTE of MINING and MECHANICAL ENGINEERS. Vol. XXXVII.

THE USE OF IRON SUPPORTS IN THE MAIN ROADS OF MINES INSTEAD OF MASONRY OR TIMBERING.

By Messrs G. MEYER and W. J. BIRD. Pp. 135-143.

THIS paper gives particulars of the cost of various forms of iron supports at present in use in several Continental mines.

At Creuzot, in France, plain bars or rails are used, which are carried by wooden props, and sometimes on brick side walls, with a lining of oak planking above the rails, and in some cases brickwork is built from bar to bar, the distance between which is 3 to 3½ feet.

In the Prussian Government Lead Mines, in the Hartz mountains, flat-bottomed rails are employed, weighing 14½ lbs. to the yard. They are bent into elliptical arches, 6′ 4″ high by 4′ 4″ wide, with the rail head inwards, and the ends of these iron arches are wedged or cemented into holes drilled into large stones set on the pavement, and which also serve as sleepers for the tramway. The arches are lined with the same kind of rails laid longitudinally, and the spaces between these runners are filled with flag stones. In the Mines' Inspector's reports this method is stated to cost 33/2 per yard, as against 55/1 for lining the same road with masonry, or 22s for timbering with props and planks.

In the Altenwald Coal Mine, near Saarbrücken, iron supports were put into a roadway where there was continuous settling of the floor due to the workings in an underlying seam. The arches were complete elliptical rings, 7ft. 8in. high by 5ft. 2in. wide, of T shaped rails, held together at the joints by bolts and fish plates, and spaced 2ft. 4in. apart, and the lining behind them was of oak planking, the cost per yard for which is put down at 58s 2d. In another road the arches were complete circles, 6ft. 10in. diameter, and wrought-iron plates were used for lining, and the cost was stated to be 95/7 per lineal yard. In a return airway, 8ft. wide and 6½ft. high, where the rails were bent so as to form a top arch and two side legs, and the lining was formed of wrought-iron plates, the cost was 101/5 per yard; and a similar method for a roadway, 6ft. 4in. wide and 7ft. high, to the crown of the arch, but with oak lining, is said to have cost 40/6 per yard.

At the Segen Gottes Pit, Austria, where a double roadway has to be maintained, the

rails are bent into the form of a Gothic arch, 7½ft. high to the crown and 7ft. wide at the bottom, the lower ends of the arch rails being connected by cross rails, to which the tramway rails are in turn fastened. It was found here that the first cost of the iron supports was 20·8 per cent. more than timbering, but after nine years' use the cost of the iron supports was estimated to be 8¼ per cent. less than timbering, which reduction would increase to 43·8 per cent. in favour of iron after eighteen years' employment. In this estimate no account is taken of the scrap value of the old rails when they come to be taken out. J. G.

THE SCHOOL OF MINES QUARTERLY, NEW YORK, Nov., 1888.

MACHINE MINING IN THE ST. LOUIS COAL REGION.

By Prof. H. S. WHEELER.

IN this paper the author discusses the comparative advantages of coal getting by hand and by machines, and states that under ordinary conditions the cost is apt to be in favour of the hand method in quiet times, but in times of brisk trade and labour troubles the machines have a decided advantage, only three skilled men and five labourers being required to get as much coal as twelve skilled miners.

The machines are working the Belleville seam; average thickness, 6 to 7 feet; fireclay holing and strong limestone roof; level, dry, free from firedamp and faults, and worked by some modification of stoop and room system, with rooms up to 45 feet wide; in short, the conditions are very favourable to machine mining.

In hand mining, two men work in a room, undercut, blast and load the coal and timber the roof, for about 50c. per ton of 2000lbs. of round coal over ¾in. to 1¼in. screen, and put out about 4 tons per man per day; the miner paying for his own tools, oil, powder, blacksmithing, etc.

In machine mining, a timber man precedes the machine, secures the roof and lays the road, and the machine, in charge of two men, follows and undercuts the coal; then comes the blaster, who blows down the coal, and he is followed by labourers, in gangs of two, who load. In this sequence five rooms per machine are required.

The machines used are made on two principles:—(1) The Legg Machine is a rotary cutter, in which a horizontal bar, armed with detachable knives at the end of a movable frame, is fed forward under the coal by a duplex compressed air engine. (2) The Harrison Machine is simply a percussion drill, in which a broad pickbit, secured to the end of the piston rod of a small engine mounted on wheels, chips or picks away the coal or fireclay. Sketches are given of both these machines. The latter is described in the Transactions of this Institute, Vol. VI., p. 77.

The Legg machine cuts about 13½ square feet, 5in. thick, 5ft. deep, with one position of the bedplate. The speed naturally varies with the nature of the holing. Pyrites, etc., impedes the progress and rapidly dulls the knives. The average work per ten-hour shift is about 380 square feet.

The consumption of air, at 60lbs. pressure, is about 40 to 60 cubic feet per minute. The weight of the machine, 1200 lbs.; and its cost from 1200 to 1500 dollars. The life of the machine is short, and cost of upkeep very heavy, but the amount of dross produced is very small.

The Harrison machine is worked on a wooden platform sloping at an angle of 5° to the face, so that the force of the blow is neutralized by gravity. The cut is about 3½ft. deep and 4ft. wide, 12in. high at front and 3in. at back of holing for one position of board. It takes 6 minutes to shift plank, 1½ minutes to change bits, 16 minutes to make cut, and about 20 minutes to take machine to next room, so that the machine is in actual operation for about 75 per cent. of the time; and the coal is left to lie in a more suitable manner for blasting than with the Legg machine.

The average area cut per shift of 10 hours by one machine is 230 feet, but a pair of men working under contract could probably cut 300.

Consumption of air, at 70lbs. pressure, is said to be from 10 to 15 feet per minute. The weight of the machine is about 200 lbs., and its cost 600 dollars. The upkeep is not nearly so heavy for this machine as for the Legg, and its life is about six years.

The author gives details of the vulnerable parts of the Harrison machine, and a complete estimate of cost of instalation at a mine with output of 400 tons per day; and also an estimate of the cost of working and upkeep, including interest and depreciation. This estimate shows the cost to be about 40c. per ton, against 30c. per ton when work is done by hand. W. T.

Proceedings of INSTITUTE of CIVIL ENGINEERS. Vol. XCIII., p. 421.
Paper No. 2345.

TRANSMISSION OF POWER TO GREAT DISTANCES BY COMPRESSED AIR.

By PROFESSOR UNWIN, B.Sc., F.R.S.

IN this paper the author gives laws governing the transmission of power by compressed air, and compares the efficiency of air and water for this purpose. He says that "under practically realisable conditions the whole frictional work in the mains may be expended in heating and expanding the air. What the air loses in pressure it gains in volume, but the fall of pressure *does* involve a loss in transmission, because the efficiency of the motor is effected; but in spite of this secondary loss, an advantage remains to the air over water, and part of the frictional work is recovered. To transmit power economically by water very high pressure and a moderate velocity must be adopted in the main, because the friction increases very rapidly with the velocity, and the whole mass of the water in the mains must change velocity simultaneously, hence the shock due to sudden changes of velocity are very serious when velocity exceeds 3 or 4 feet per second.

"Both the high pressure and low velocity limit the size of main which can be used, and therefore the amount of power which can be transmitted by water.

"With air the unavoidable heating losses in compression limit the pressure which can be used, and it is doubtful whether efficiencies quite so great as those with water can be realised with air, but there appears to be no limit to the amount of power which can be transmitted by air if necessary."

Water can only afford work less than the product of its pressure and volume, but air used expansively gives an amount of work greater than the product of its pressure and volume. Hence it turns out that with a given size of main, a considerably greater amount of power can be transmitted by air at a moderate pressure (say 50 to 70 lbs. per square inch) than with water at a very great pressure (700 to 1000).

Any arrangement for transmission of power by a fluid consists essentially of a pump to compress, a main to carry, and a motor to liberate the fluid.

Formulæ are given to show the loss of energy in each of these parts, and to show the combined efficiency of the arrangement—first, when water, then when air is the medium. The formulæ are worked out for special cases, and a graphic representation is given of the combined action of pump and motor with air. These formulæ show that (1) with water at high pressure and low velocity the friction in the mains has very slight effect on the efficiency of the arrangement; (2) with air a considerable fall of pressure in the mains does not materially affect the efficiency; (3) with air, pressure varying between 30 and 80 lbs., the efficiency only varies 2 %, while great economy is obtained by using the high pressure in the matter of first cost of mains. Generally, the author draws the following conclusions:—"The resultant efficiency of pump, main, and motor is likely to be somewhat lower for air than for water, unless the heating loss in the compression pump can be diminished more than it has hitherto been by cooling arrangements. On the other hand, air has considerable advantages in some other respects, especially that with a low initial pressure, a greater quantity of power can be transmitted through a main of a given size than with water. Re-heating at the motor would greatly increase the efficiency of air." W. T.

Proceedings of the SOUTH WALES INSTITUTE of ENGINEERS.—Vol. XV.

SHOT FIRING IN MINES.

By Mr WILLIAM GALLOWAY. P. 410.

THIS is the third part of a paper on blasting in mines, and is taken up with a description and details of the experiments undertaken by the author, for the Royal Commission on Mining Accidents, with liquid carbonic acid cartridges for the prevention of flame in blasting. There is also noted the trials made with plug and feathers, with weights, and with Humble's plugs, for the prevention of blown-out shots; and there is an account of the apparatus used for making experiments with various explosives in the presence of coal dust and fire-damp, the details of which are mostly tabulated in the report of the Royal Commissioners.

The paper concludes with a description of the Altoft's Colliery explosion, illustrated by a plan, which the writer considers the best example of a true coal dust explosion, uncomplicated by the presence of fire-damp, that has ever occurred. The mine was well aired and almost free of gas, and the explosion was caused by a shot fired while repairing the intake, near the pit bottom. All the air crossings were blown into the return air-ways, and the flame traversed all the main intake roads except one, but in no case did it reach the face or pass into the returns. The stables were near the entrance to the only intake into which the flame did not pass, and the water used there kept the pavement constantly wet, so that the flame was not propagated, for want of dry coal dust to sustain it. J. G.

Proceedings of INSTITUTE of CIVIL ENGINEERS, Vol. xciii., Page 421.

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minute; the weight of the machine, 1200 lbs.; and its cost from 1200 to 1500 dollars. The life of the machine is short, and cost of upkeep very heavy, but the amount of dross produced is very small.

The Harrison machine is worked on a wooden platform, sloping at an angle of 5 deg. to the face, so that the force of the blow is neutralised by gravity. The cut is about 3½ ft. deep and 4 ft. wide, 12 in. high at front and 3 in. at back of holing, for one position of board. It takes 6 minutes to shift the plank, 1½ minutes to change the bits, 16 minutes to make the cut, and about 20 minutes to take the machine to the next room, so that the machine is in actual operation for about 75 per cent. of the time, and the coal is left holed in a more suitable manner for blasting than with the Legg machine. The average area cut per shift of 10 hours by one machine is 230 ft., but a pair of men working under contract could probably cut 300. Consumption of air, at 70 lbs. pressure, is said to be from 10 to 15 cubic feet per minute; the weight of the machine is about 700 lbs.; and its cost 600 dollars. The upkeep is not nearly so heavy for this machine as for the Legg, and its life is about 6 years. This machine is figured and described in the Transactions of this Institute, Vol. VI., p. 77.

The author gives details of the vulnerable parts of the Harrison machine, and a complete estimate of cost of installation at a mine with output of 400 tons per day, and also an estimate of the cost of working and upkeep, including interest and depreciation. This estimate shows the cost to be about 40c. per ton against 50c. per ton when work is done by hand. W. T.

Transactions of NORTH of ENGLAND INSTITUTE of MINING and MECHANICAL ENGINEERS. Vol. XXXVII.

EXPLOSION OF AIR RECEIVER AT RYHOPE COLLIERY.

REPORT OF COMMITTEE. P. 197.

IN 1883 an egg-ended boiler, 6ft. in diameter and 29ft. long, used as an air receiver at Ryhope Colliery, exploded. The safety valves on the receiver were loaded to blow off at a pressure of 50lbs., and when the pressure had risen to 58lbs. the air escaped by the valves as quickly as it was pumped in. The air compressors were not equal to forcing air into the receiver against a pressure much higher than this, so that the actual pressure at the time of the explosion must have been far below what the receiver was capable of sustaining. The damage was not confined to the receiver itself, but extended to the pipes conducting the air down the shaft. Several of these pipes had burst, doing great damage to the shaft fittings, while an air crossing 1000 yards from the shaft was "lifted." An examination of the ruptured receiver shewed that part of the shell had been at a white heat. Eye-witnesses observed a fierce flame issuing from the receiver at the time of the explosion, and afterwards burning brightly within the remains of it. All the facts pointed to the bursting of the boiler being caused by the explosion of some substance inside it, and not simply by the pressure of the air. No observations of the temperature of the air delivered by the compressors at the time of explosion are recorded; but the facts appear to point to the temperature in the receiver being high—one of the enginemen stating that the thermometer had been known to indicate as high as 300° F., although 180° F. was the common temperature. The lubrication of the air cylinders was effected through the suction valves, into which one gallon of fluid, composed of 2lbs. of soft soap mixed with half a gallon of mineral oil and an equal quantity of water, was poured every two hours. Formerly, a lubricant of the same composition, except that the oil used was colza oil, was admitted by screw inlet valves connected by pipes with the receiver, whence sufficient of the lubricant was drawn in at each stroke, any excess being returned to the receiver along with the air. This method was discarded because of the difficulty of preventing a deposit in the air pipes. This deposit, composed

of the constituents of the lubricant mixed with coal dust, was present in the receiver at the time of explosion. The presence of mineral oil in the deposit is a point to be noted. To explain the explosion there are two conditions necessary. First, conditions capable of producing a temperature sufficiently high to ignite an explosive mixture of air and combustible gas; and, secondly, the production of such an explosive mixture. Professor Bedson conducted experiments with the object of determining whether the circumstances at Ryhope explained the fulfilment of these conditions. He claims to have established experimentally that, "with an easily oxidisable material, such as coal dust, (a constituent of the deposit in the receiver), it is only necessary to accelerate the oxidisation by heating the dust in contact with air to a temperature within the limits of those likely to be reached in compressing air to 58lbs., in order to bring about in course of time the ignition of the dust." This conclusion he reached from experiments with very small quantities of dust, a fact of much importance, seeing that in his own experiments 1oz. of dust ignited at 356° F., while under similar conditions 10ozs. ignited at 291° F. The experiments proved the deposit found in the air receiver much more refractory than pure coal dust. Indeed, Mr Bedson did not succeed in procuring ignition thereof. He held, however, that the result would ultimately be the same, and that, combustion once begun, destructive distillation of adjoining portions would be produced by the heat generated, From such distillation a combustible gas would result, which, mixed with the air, would produce an explosive atmosphere capable of being ignited by the burning material. In concluding the report, the committee insist upon the importance of careful selection of sites for air compressors, so as to be beyond the influence of gasworks or other source of inflammable or noxious gases, which might be conveyed into the mine with the compressed air; also of keeping them clear of coal dust from the screens, and of having sufficient water jackets for the air cylinders. The danger of lubricating air cylinders with mineral oil is obvious. J. H.

STEEL SUPPORTS FOR MAIN ROADS IN CLEVELAND MINES.

By A. L. Steavenson. P. 221.

Before substituting steel for wood, Mr Steavenson made certain rough experiments upon their relative strengths. These experiments were carried out in the mines upon full-sized specimens of timber balks and steel girders to be used underground. His results shew that the form of steel girder he adopted, of the usual H shape, weighing 50lbs. per yard, is capable of supporting at least double the load of a timber balk 8in. in diameter in the small end, the size commonly in use in main roads of Cleveland mines. So far, steel has stood the test of actual work, only one girder out of 200 tons in use having broken. One advantage of steel or iron frames for underground roads is the small percentage of the area of the roadway taken up, as compared with timbering or brick arching. According to a French authority, iron or steel supports leave a clear space equal to 81 per cent. of the roadway, against 52 per cent. for timbering and 37 per cent. for brick arching. In cost, the comparison of steel and wood at Cleveland for a particular form of work, including labour, gives for steel £5 4s 1d, and for timber £3 16s 6d, or "36 per cent. as the cost of permanency or greater efficiency," as Mr Steavenson puts it. From what he described as "every-day" experiments on small samples, there have been deduced the following strengths of timber in pounds suspended from the centre of a beam 1in. square on supports one foot apart:—Riga=475 lbs., Norway=460 lbs., Larch=395 lbs. In the discussion of the paper, Mr Steavenson gives as his opinion of creosoted timber, that to cut it, or even drive a nail into it, destroyed the effect of the creosoting; while another speaker thought that cutting did not absolutely injure timber treated thus, adding that he knew a case where it had lasted upwards of twenty-four years, and yet shewed no sign of decay. J. H.

Transactions of the NORTH of ENGLAND INSTITUTE of MINING and MECHANICAL ENGINEERS. Vol. XXXVII.

A CONTRIBUTION TO OUR KNOWLEDGE OF COAL DUST.

BY PROFESSOR BEDSON. P. 245.

IT had been observed by a colliery manager that in screening a certain coal the dust would rise in a cloud, and occasionally ignite at the lamp in use in the screens and cause a species of explosion. Professor Bedson undertook an investigation of the coal dust from this seam, in the expectation that the phenomenon referred to was caused by combustible gases enclosed in the coal. Von Meyer's experiments on coal subjected to the temperature of boiling water proved the existence of quantities of gas occluded in the coal varying from one-third to nearly three times the volume of the coal itself. The composition of these gases was in most cases a mixture of carbonic acid, oxygen, nitrogen, and fire-damp, in varying proportions. The same scientist also proved that when coal had been exposed to the atmosphere for a time, not only the quantity of gas but the composition thereof altered. Weathered coal gave off certain hydro-carbons not found in coal fresh from the pit. Thomas afterwards experimented in the same direction, with similar results; but pointed out that all the gases were not driven off at the temperature of boiling water. or even at 300° F., when decomposition is on the point of starting. He found that anthracite gave off most gas, followed in order by steam and bituminous coals in a way that seemed to shew that the volume of gas given off was dependent upon the structure of the coal. These experiments were made on coal, while Professor Bedson directed his attention to coal dust. The temperature to which the dust was exposed was the same as before (212° F.), and the quantity of gas given off varied in three experiments from one-half to eight-tenths of the volume of dust, if compressed to consistency of coal. The point in the result obtained to which special attention is directed is that an analysis of the gas shewed the presence of certain hydro-carbons other than fire-damp in considerable proportion. In one experiment the gas given off at various temperatures under that of boiling water were noted, and subsequent analysis proved that the proportion of hydro-carbons in the gas steadily rose with increased temperature. The small percentage of fire-damp obtained from the coal dust, compared with what Von Meyer and Thomas got from coal, is supposed to be due to the finer sub-division of the particles having facilitated the diffusion of the lighter fire-damp, leaving a larger proportion of the heavier hydro-carbons. As these latter required more oxygen for their complete combustion, a smaller percentage thereof in the atmosphere, than is required in the case of fire-damp, would form an explosive mixture. It is proposed to continue the investigation. J. H.

THE SOUTH WALES INSTITUTE OF ENGINEERS. Vol. XVI.

PERRET'S FURNACE, OR WATER-CASED GRATE FOR BURNING DUST FUEL. P. 50.

THIS furnace is a French invention, designed to burn very small coal or coal dust, such as ordinary grates are not suited for consuming. It can be applied to any form of boiler furnace. The furnace bars, which are ⅝in. broad on the top, tapering to ¼in. on the under side, are 9in. deep, and have an open space of only 3/32 of an inch between them, through which the air passes by forced draught. The bars have their lower edge immersed to a depth of three inches in a trough of water, which is supplied from a small tank, wherein the water level is controlled by a ball cock. The furnace door is air-tight, and the draught is forced into the space between the surface of the water in the trough and the top of the fire-bars by means of a 22in. fan running at 1500 to 2000 revolutions per minute, or by a Körting's steam-jet, supplied from the boiler. The combined effect of the water bath for fire-bars and of the forced draught is said to keep the fire-bars so cool that, "on pushing back the glowing fuel from the front of the bars, the hand can be held

without inconvenience on the spot where, but a moment before, a bright fire was burning.' Consequently, the clinker is easily removed from the fire-bars, and these consequently last very much longer than is generally the case. This furnace appears to afford a means of utilising the finer products of coal washing. J. H.

THE MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS. Vol. XL.

TONITE AS AN EXPLOSIVE WHEN USED WITH A FLAME-DESTROYING COMPOUND.

BY W. HARGREAVES. P. 289.

TONITE is a blasting agent which does not explode by concussion, and may be burned openly without risk. The explosion of Tonite when blasting is accompanied with flame, but a compound has been discovered, for which the property of being able to prevent any emission of flame is claimed. This flame-destroyer is composed of sawdust, saturated with some chemical. When used, it is put into the shot-hole so as to surround the cartridge completely except on the under side. The charge is fired by electricity. Like all high explosives, Tonite breaks up coal very much; and, in order to diminish this effect, a sprag is put into the holing directly under the shot-hole. This is found to secure a better distribution of pressure and prevent excessive disintegration of the mineral. In brushing, means must be taken to secure a similar effect, otherwise the material blown down is useless for buildings. Costs given are very unfavourable for Tonite as compared with powder, and only the absolute necessity of preventing the emission of flame, which is said to be secured by the compound described, can make it worth while to use the former in preference to the latter. So far as Mr Hargreaves' experiments go, it is a question whether Tonite thus used is better than powder used with water cartridge. The evidence so far can only secure a verdict of "not proven."

IN MR BLAKE WALKER'S "NOTES ON MATTERS OF CURRENT INTEREST" (P. 247), there is a description of

A TOOL WHICH IS DESIGNED TO DO AWAY WITH THE NECESSITY FOR HOLING.

A SHOT-HOLE having been bored in the ordinary manner, what is called a "chambering tool" is used, by means of which a triangular cavity is cut at the inner end of the drill hole. Into the lower half of this cavity, the explosive substance is placed. A wooden plug is driven into the hole, over and outside the charge, and tamped. The charge is fired by means of a fuse. The explosive has thus a surface at right angles to the plane of the seam to act upon, and consequently exerts a thrust outwards towards the face, which, it is supposed, will render holing unnecessary. There is also a note on

A SAND CARTRIDGE

—An Austrian invention. Arguing from the power of gauze to prevent the passage of flame, the inventor surrounds his explosive cartridge with a layer of wet sand, which, he holds, plays the same part in relation to the flame of explosion as does the gauze round the flame of a safety lamp. The water is converted into steam, and so reduces the temperature below the ignition point of fire-damp. Will the effect of the explosion not be correspondingly reduced? J. H.

JOURNAL OF THE BRITISH SOCIETY OF MINING STUDENTS. Vol. XI.

NOTES ON A VENTILATING CURRENT.

By HENRY PALMER. P. 46.

WHAT percentage of the air current passing in the downcast reaches the working faces? is a question which, it is to be feared, will not always stand close investigation. It

sounds better to say the ventilating current is so many tens or hundreds of thousands of cubic feet. Mr Palmer gives measurements of a single split of air taken at various points from the bottom of the downcast to the face. Starting with close on 17,000 cubic feet, 140 yards from the shaft, the current is diminished to 13,000 cubic feet at 465 yards, and 12,500 cubic feet at 805 yards from the shaft. At the face of the workings, 2206 yards from the shaft, the current measured 1560 cubic feet. Allowing for two sub-splits, amounting together to 6650 cubic feet, we have a loss by leakage equal to 8440 cubic feet in the 2200 yards travelled by the air from shaft to face—that is, that, in the case before us, only 15·6 per cent. of the ventilating current in this one split reached the face. Provided the quantity that does actually get to the working face be sufficient for the requirements there, what leaks through stoppings, &c., on the way is not necessarily useless; but the loss in this case shows a wasteful expenditure of power in producing ventilation. In how many collieries would similar tests give like results?

At Page 48, FRANK BRAIN gives

NOTES ON THE APPLICATION OF ELECTRICITY TO MINING WORK

—For lighting, pumping, and haulage. He gives a short description of a pumping plant with which he was directly connected at Trafalgar Colliery. This installation gave 35 per cent. effective results, while another at Normanton yielded 44·4 per cent. In neither case was the engine designed for the work it was set to do. What is being done in the same direction, both in America and on the Continent, is also shortly detailed.

J. H.

Transactions of THE LIVERPOOL ENGINEERING SOCIETY. Vol. VII.

A STRANGE FAILURE OF STEEL BOILERS.

By A. J. MAGINNIS.

Two sets of steel marine boilers were fitted into two ocean steamers engaged in the Colonial and Transatlantic trade. The material employed passed all tests required by the Board of Trade and Lloyd's, and also stood quite satisfactorily all the welding and other work of the boiler shops. Both sets of boilers worked for 2½ years, and thereafter serious defects, due to a complete change in the nature of the steel, were rapidly developed. From time to time cracks suddenly appeared in the plates, generally some time after steam had been blown off, and the only work going on was scaling or repairs. The cracks were in the combustion chamber, and the first ones occurred with a deafening report. Tests were applied by striking the plates with a seven-pound hammer, with the result of cracking three different plates. Sometimes the crack was preceded by a dark band about half-inch broad along the line ultimately taken by the crack. Another blow developed a fine hair line, which gradually widened into a fully developed crack. After the first failure, strips of the damaged plate were subjected to mechanical and chemical tests without disclosing any change that could account for what had occurred. The analyst reported that, chemically speaking, "the steel is not at all objectionable, being a material of a good average quality." The tests of tensile strength and elongation gave, as the lowest tenacity, 24·24 tons per square inch; and the smallest percentage of elongation before rupture was 8 per cent. The cracked plates were subjected to various tests, such as fixing one side of the plate firmly and striking the portion beyond the crack with a sledge hammer. "With one plate, the first blow extended the crack about 4 inches, leaving only 2¼ inches more of solid plate; this remaining portion was then hammered flat down and again straightened, without in the least extending the crack." Similar tests applied to another plate produced like results, while part of it snapped like a piece of glass with a single blow. The boilers were ultimately removed from the steamers, and broken up. During that operation, the behaviour of the material was quite in keeping with the experience gained during the experiments on the ruptured plates. The author of the papers does not attempt any explanation of the phenomena he records.

J. H.

The JOURNAL of the IRON and STEEL INSTITUTE. No. 2, 1888.

THE OIL SHALES OF THE LOTHIANS. P. 150.

THIS paper is by Mr H. M. Cadell, sometime on the staff of the Geological Survey of Scotland. Oil shale he describes as fine clay shale, which on distillation yields on an average thirty gallons of crude petroleum per ton, and ammonia sufficient to form ten to forty-five pounds of ammonia sulphate.

Edinburgh stands on the ridge of an anticline, with the old red sandstone close to the surface. The strata dip away to both sides—at a high angle to the east, bringing in the coal measures at a short distance, but flatter towards the west, so that on this side there is a long stretch of country exposing the lowest portion of the carboniferous formation known to Scotch geologists as the calciferous sandstone series, and which includes all the rocks underlying the Hurlet limestone. In the upper portion of this series the oil shales of the Lothians chiefly occur. The rocks consist of grey sandstone, among them the Binny sandstone; of carbonaceous shales, fireclays, thin concretionary limestone or cement stones—locally known as marls—with at least one bed of fossiliferous estuarine limestone, the Burdiehouse or Camps, which is much worked for iron making.

Mr Cadell gives a general section of the carboniferous limestone and calciferous series, and describes the small basin-shaped areas and the characteristic steep ridged and contorted nature of the shale fields, which have been crumpled by great convulsions and invaded by extensive volcanic intrusions. The slow formation of the beds in the tranquil pools of a gradually subsiding estuarine or fresh water area, surrounded by less quiet spots, is indicated to account for shales thick and rich at one place, dying out rapidly, and passing into blaes at another.

Transactions of the AMERICAN SOCIETY of MECHANICAL ENGINEERS. Vol. IX.

CENTRIFUGAL PUMPS AND THEIR EFFICIENCIES.

By Mr W. O. WEBBER. P. 228.

AFTER stating that in 1851 Mr Appold exhibited his pump at the great London Exhibition, and had previously determined that its efficiency mainly depended on the blades curving back and pointing in the opposite direction to that in which the fan revolved, and on the casing taking the shape of a spiral tapering pipe or volute, Mr Webber proceeds to quote largely from a paper in the transactions of the Institution of Civil Engineers on "The History and Theoretical Laws of Centrifugal Pumps," by the Hon. R. Clere Parsons, who in 1875 made some experiments with a view to determining the conditions which regulate the discharge of such machines. The first comparison was between an eighteen inch Appold's fan with ten inch suction and discharge pipes and circular casing, and the same fan working in a spiral casing, when it was found that the efficiency in the latter case was considerably greater. Substituting a fan with blades curved on the principle laid down by Rankine and using the same casings as before, the tables of results are stated to prove that with both circular and spiral casings Rankine's blades are far inferior to Appold's. This is, however, not very apparent. From these and other experiments, Mr Parsons deduces that the internal angles of the blades should vary both with the height of the lift and the quantity to be discharged, and that the passages should be proportioned so that the velocity of the entering water should gradually increase until it reaches the circumference of the disc, and from that point gradually decrease until it issues from the discharge, and that the velocity on leaving the fan should not be more than twenty-four to thirty feet per second. From the discussion it appears that the theory of centrifugal pumps, like the mechanics of centrifugal ventilating fans, is not as yet altogether understood, and their efficiency probably depends a great deal on their being driven at the speed for which they were designed.

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